The Blast Furnace and Steel Plant

Uniflow Steam Engine for Rod Mill Drive

Nordberg Uniflow Used as Drive for Roughing Stands on Continuous Rod Mill at Youngstown Sheet & Tube Company's Struthers Plant—Electric Drive on Finishers.

By **CHARLES C. LYNDE.**

One of the large extensions of the Youngstown Sheet & Tube Company which was authorized last year, and on which construction was at once begun, is the new merchant mill plant at the Struthers, Ohio, plant, of the Youngstown Sheet & Tube Company. This plant is laid out in two sections, one section a nine-inch mill, and the other caring for a twelve-inch unit. At an angle to the main sections covering the mills proper, and across the end, is a building for handling the incoming stock, and arranged to give

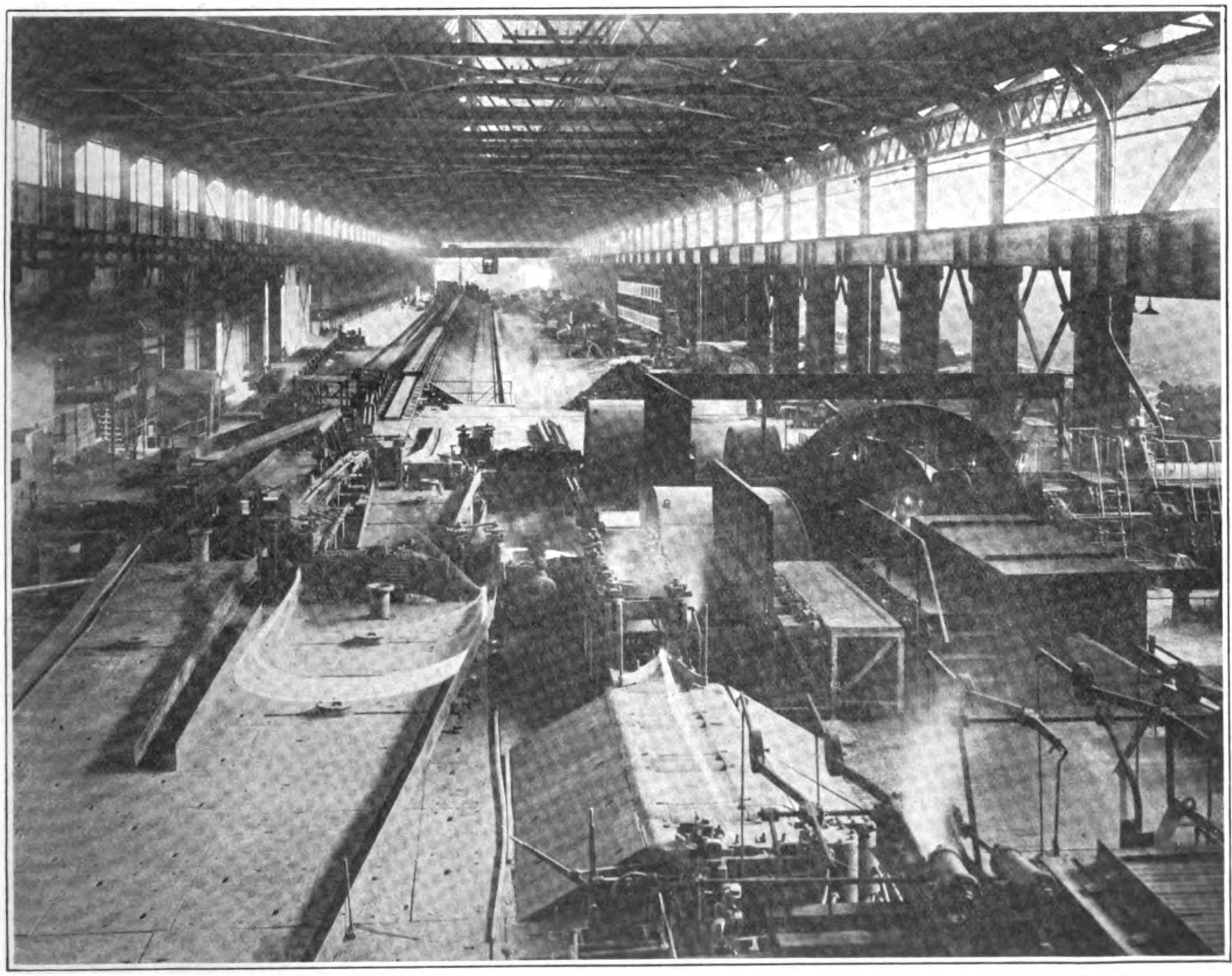


Figure 1.—General view of the nine-inch side of the new rod mill with looping strand in the foreground—Compact arrangement of all units here appears—At the right of the main floor beside the cooling bed appear piles of brick and other materials assembled for completing work in t he twelve-inch mill alongside.

unloading service for the bars as they come in from the company's other plants. Here an overhead crane unloads the bars from the railroad cars and stores them on a platform to await transportation to the feed side of the heating furnaces serving the mills. The stock is carried on a roller table and mechanically charged, its progress through the inclined bed of the furnace being due to the charging of new material and the withdrawal of the heated stock as it goes to the rolls. At the other end of the plant is a similar diagonal building, housing the cranes for loading the rod or other finished product from either mill onto railroad cars for re-shipment to some of the using departments of the plant, or for freighting direct when the plant has completed its working of the material.

The nine-inch mill is in a building 90 x 1,150 feet in extent, and the twelve-inch in a section 100 x 1,200 feet. The building is of the usual structural steel type, with a Pond type roof.

Drive for the nine-inch mill is a combination of steam and electricity. The roughing stands of the nine-inch mill are driven by a single cylinder Nordberg uniflow engine, 37 x 48 in., connected to the six roughing stands through a progressive bevel gear drive. The gearing on these roughing stands is such as to give an approximate speeding up of the consecutive stands so as to absorb the major portion of the elongation of the stock as it is formed. The entire mill consists of six stands of twelve-inch roughing and six of nine-inch finishing, and one Edwards sizing mill. The two finishing stands, No. 7 and No. 8, are driven by a 700-horsepower Crocker-Wheeler direct-current motor, while the Nos. 9 and 10 and Nos. 11 and 12 stands are driven by 600-horsepower Crocker-Wheeler motors. A 100-horsepower direct-current motor, Crocker-Wheeler, drives the Edwards sizing mill.

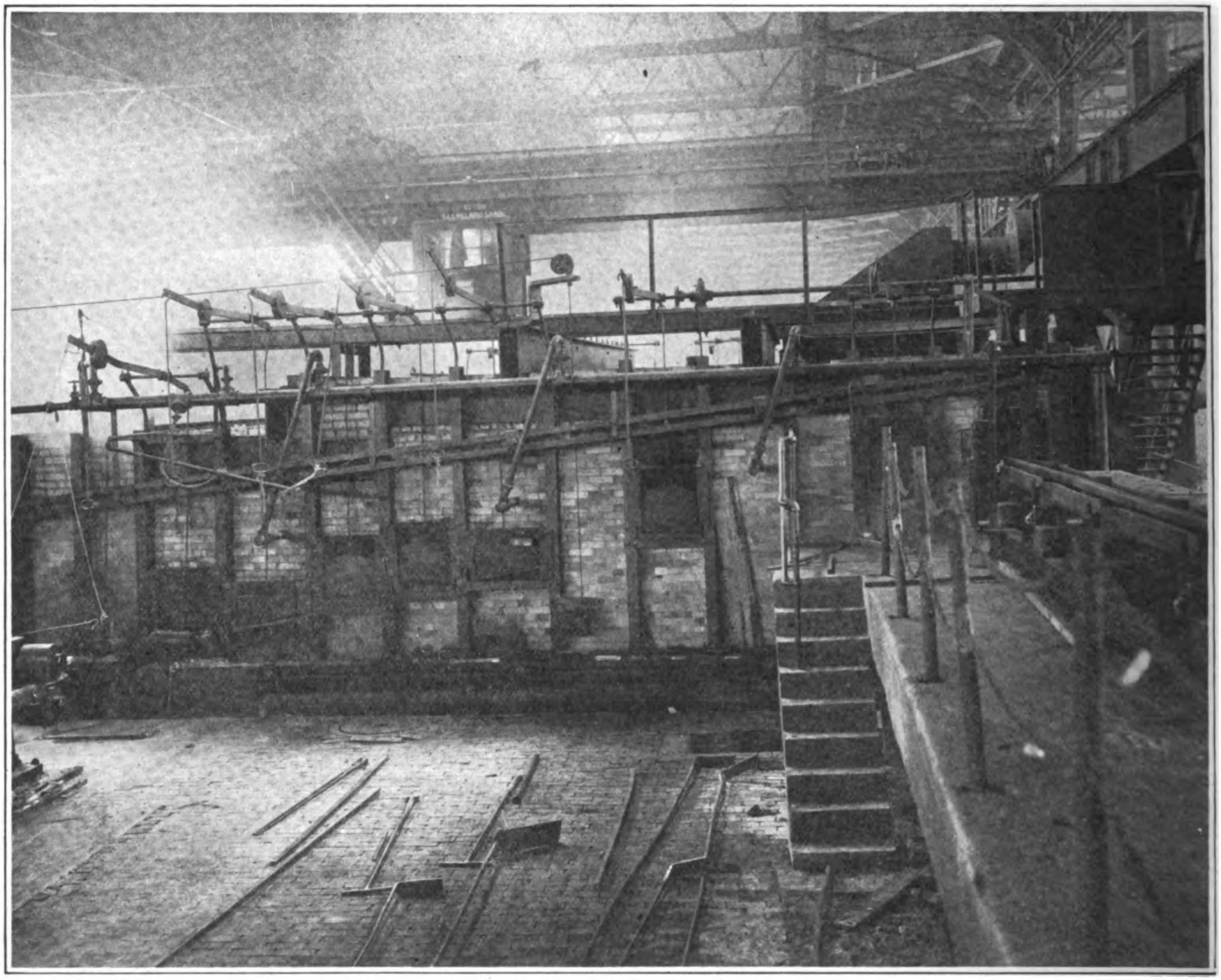
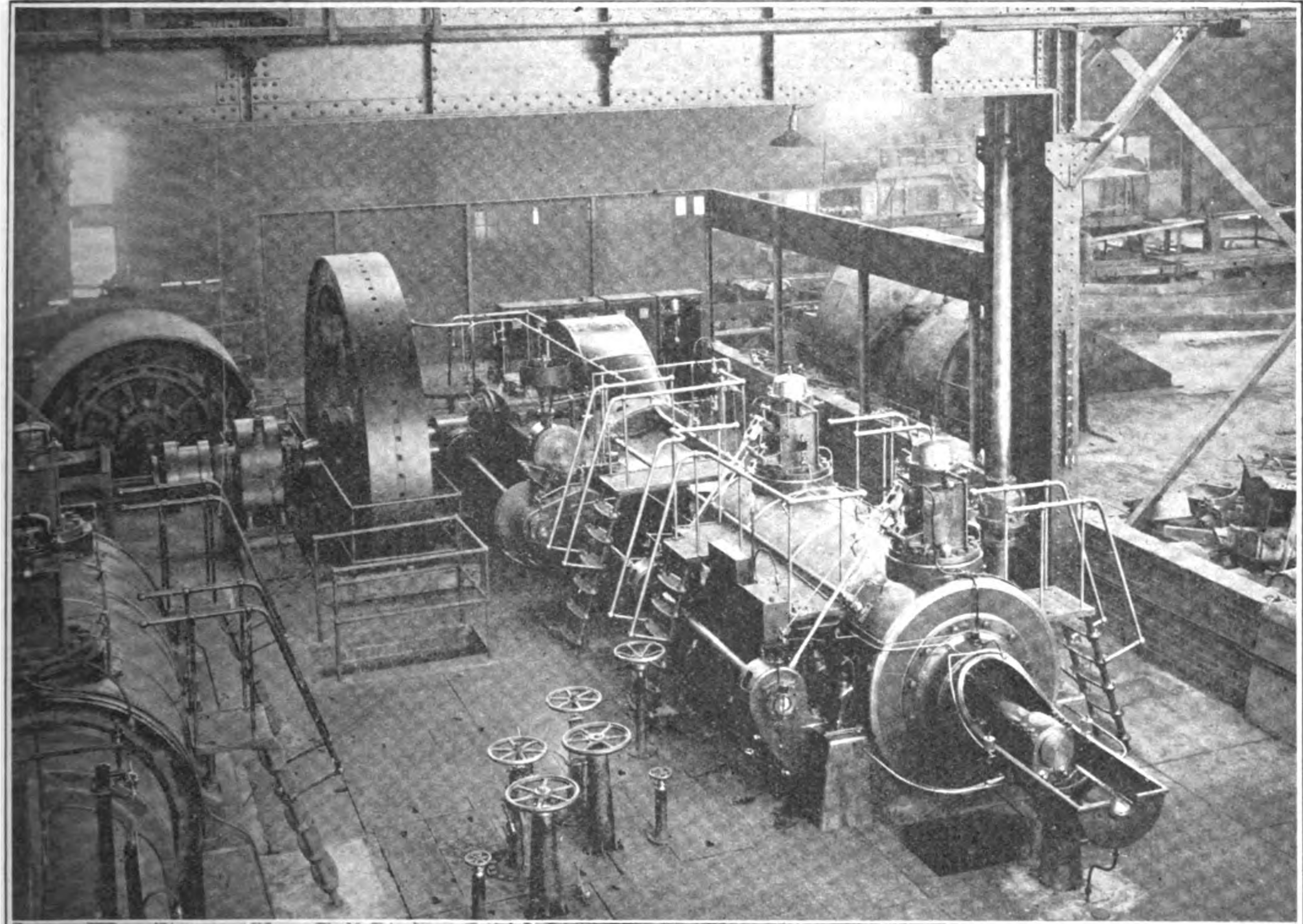


Figure 4.—Charging side of nine-inch mill heating furnace, wherein may be seen some of the permanent features of the plant and the care for safety provisions.

The twelve-inch unit is as yet not completely installed, but when put in will be driven by a 44 x 50 in. Nordberg uniflow engine. The normal capacity on average sections will be 10,000 tons per month.



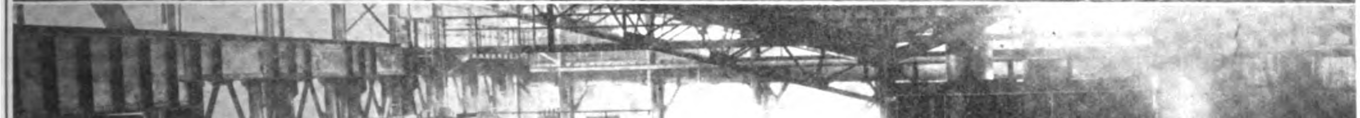


Figure 2.—View of Nordberg unit, showing general location with respect to mill—Note governor drive and safety shaft feature—Figure 3 (below) Engine, mill, and one of d. c. motors for driving finishing stands—In the central foreground appears the underground provision for looping of the metal during drawing.

The general layout of the nine-inch mill is shown in Figure 1. The last four roughing stands are shown with a bar entering, while the same piece is shown on the looping floor passing through Nos. 7 and 8 stands. The motors driving the finishing stands are shown covered with sheet steel hoods, for their better protection against dirt and flying cobbles. At the right of the roughing stands is the steel cover housing the reduction bevel gears driving the roughing stands, each connected to the engine shaft.

The general arrangement of the Nordberg engine is shown in Figure 2. At the extreme left of the view is the partially-erected 44 x 50 in. uniflow unit for the twelve-inch mill, whose final drive will be away from the nine-inch stands and toward the photographer. At the extreme left of the picture can be seen the 700-horsepower C-W motor driving No. 7 and No. 8 stands.

The governor drive on this engine consists of the lay shaft shown between the flywheel and the engine proper, driven from the crank shaft by a spiral bevel drive. At the end of the shaft is carried a steel disk, and directly over this disk a similar one on the governor shaft. Drive is transmitted between these disks by a friction member, consisting of four fibre-faced wheels, running in pairs on opposite sides of the two disks. These wheels are keyed to two shafts and are a fixed distance apart. Then, to regulate the governing speed of the engine, it is necessary only to vary the position of this drive unit so as to vary the revolution ratio of the two disks. The governor is of the balanced fly-ball type, actuating the cut-off release rod through a dash-pot control. The governor is very sensitive, taking the load almost instantly as the heated bar enters the first roughing stand, and building up perfectly to carry the increase as the additional stands take up their share of the reduction. As the bar passes through the roll stands and the load diminishes the governor acts quickly to reduce the steam admitted and thus to slow the engine.

Oiling of the engine is secured through a force-feed system, all oil draining back to a filter and being purified before being sent through the oil mains again. A Richardson-Phenix unit is installed, and the lubrication of the engine taken care of through the filters in connection therewith. The oil leads on the engine may be seen from inspection of the view in Figure 2.

The mill view of the engine is given in Figure 3, which also shows the 600-horsepower motor housing for the Nos. 11 and 12 finishing stand drive. The engine is protected against accidental damage from crane loads by the structural steel erected on the mill sides, while the lower part of the partition is utilized as a place for the series of bins erected to hold the bolts, spares and other small parts required around the plant.

In the center of the foreground appears an interesting method adopted for eliminating a part of the looping of the red-hot metal on the floor. Between certain passes the strip is shunted down the chute in the foreground, and allowed to take care of its extension in the space provided under the floor.

This same view shows the pipe leads used to convey the rods from the finishing stand to the Edwards pouring reels, four in number, which are arranged at the end of the annealing bundle conveyor. The mills, furnaces, cooling tables, and other equipment pertaining directly to the mill, are all from the Morgan Construction Company, Worcester, Mass., while the crane service is from the Cleveland Crane & Engineering Company.

Some of the safety features, as well as the permanence built into this unit of the sheet and tube plant, may be found in Figure 4, showing the bar heating furnace for the nine-inch mill. The steps at the right are monolithic concrete, and a unit with the platform to which they lead. Along the edge of this walk are set heavy pipe posts, carrying the two safety chains which guard the edge. The power driven furnace charger is shown at the right of the view, with a bar in transit. The fan system providing furnace draft is located above the furnace, and platforms around this unit are provided with toe boards and rails—as are all such exposed walks in this building.

The nine-inch mill, equipped with reels and a cooling bed, is able to turn out a large variety of shapes and types of rods, either to fill needs within the plant for its own manufacture, or according to specifications from the outside. Either bed or reels can be used as desired, with no change in set-up.

A Reply to Mr. H. G. Geissinger's Discussion.

To the Editor, **The Blast Furnace and Steel Plant:**

The writer has studied with much interest the discussion of Mr. Geissinger of the curves for the flow of gases through standard orifices. He cannot agree with him that his method of plotting the curves is simpler, because, in the derivation of Mr. Geissinger's equation it is necessary to solve the fundamental equation for flow in order to determine some of the constants.

The derivation of the general simplified formula to apply to any gas is not based on the theory of the flow of elastic fluids and the writer feels that, in general, if rigid analysis will give the required results, the empirical equations should not be used.

The statement that the simplified equation applies to steam as well as other gases is not only true so long as the steam remains in a gaseous state, but when saturated steam expands adiabatically through an orifice, condensation takes place and other means must be used to find the quantity flowing.

Mr. Geissinger's equations are very valuable for field work, where calculations are usually made by the slide rule and the results are close enough for all practical purposes.

T. G. Estep, Jr.

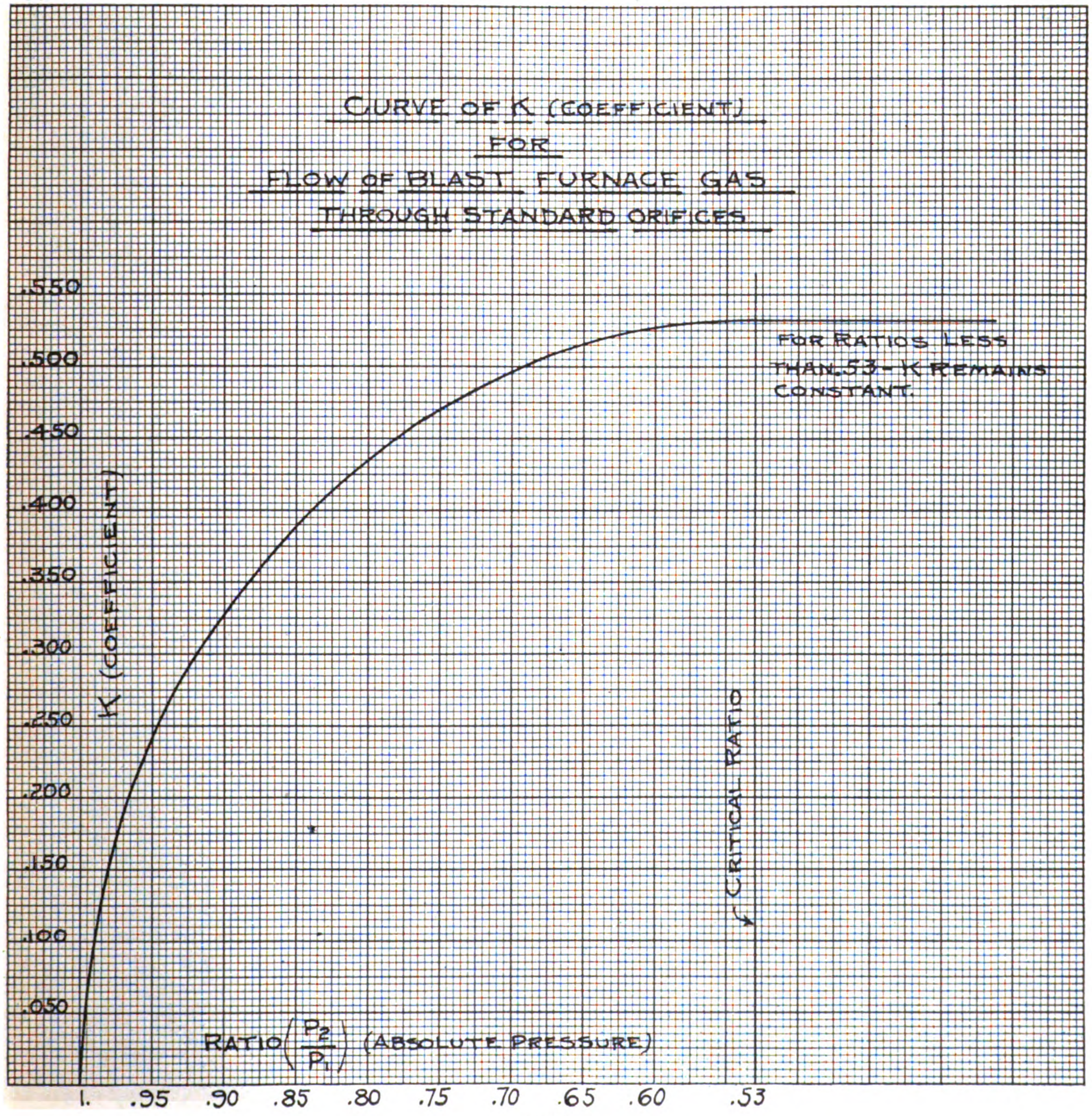
Coefficient Curves for Stack and Oven Gas

Presenting Further Discussion of the Orifice Method of Measuring Gas Volumes—Curves Given for Blast Furnace and Coke Oven Gas to Simplify Measurements.

By THOS. G. ESTEP, JR.

In the January issue of **The Blast Furnace and Steel Plant** it was recommended that the standard orifice be used more extensively for measuring the flow of gases because this method requires very little apparatus and leads to very accurate results.

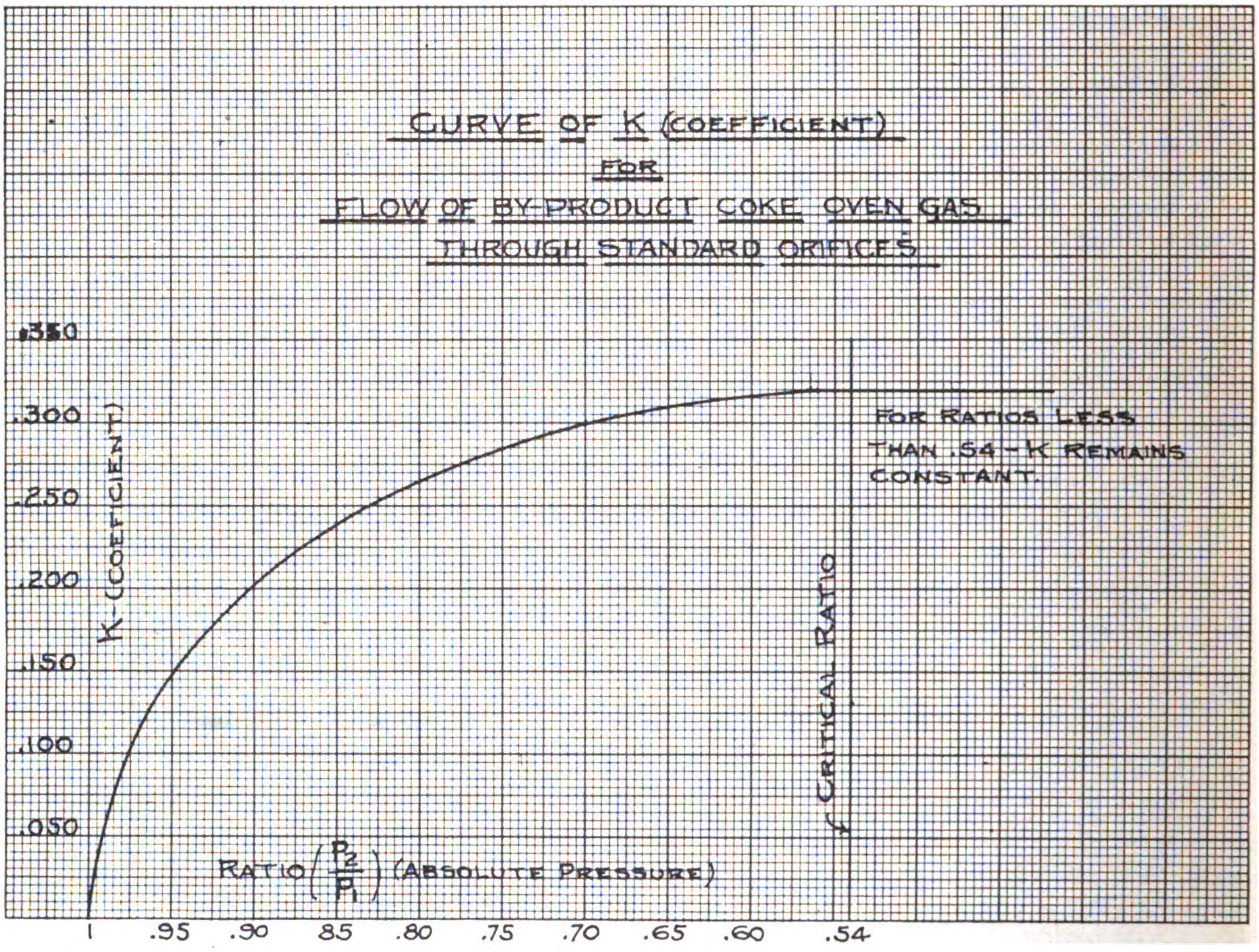
Curves were plotted using the ratio of pressures on the two sides of the orifice as abscissa and a coefficient K as ordinate. By means of the curves, the work of solving the general equation for flow was very much simplified. The former curves were for air and natural gas. Curves are now presented for blast furnace gas and by-product coke oven gas.



To use the standard orifice method of measuring gases it is only necessary to insert the orifice in the pipe line or the receiver, note the pressure on the two sides of the orifice and the temperature on the flow side. Then determine the ratio of pressures on the two sides of the orifice, from the proper curve find the value of K for this ratio and substitute in the following simple formula:

$$W = \frac{A\ P_1\ K}{\sqrt{T_1}}$$

Where W = weight of gas flowing, pounds per second.
A = area of orifice in square inches.
P_1 = pressure on the flow side of the orifice, pounds per square inch absolute.
T_1 = absolute temperature of the gas on the flow side of the orifice, deg. F. or observed temperature plus 460.
K = coefficient from curve.



The derivation of this simplified equation was given in the previous article. The equation is not empirical but based on fundamental theory.

The above equation, however, is based on two assumptions, first, that the coefficient of discharge of the orifice is unity and, second, that the velocity of approach is zero. The coefficient of discharge is not unity but will vary slightly under various conditions, from about .92 to .98. The velocity of approach is never equal to zero, but where the orifice is placed in a receiver it is so nearly so that it may be neglected. Where the orifice is placed in a pipe line (the most common case) and the pressure drop is large then the velocity of approach may also be neglected, but where the pressure drop is small it should be considered. To take this into consideration in the fundamental equation makes it somewhat complicated and it is necessary to solve this complicated equation for each separate problem, as no curves can be plotted to help out. Fortunately the problem is not as serious as it appears for it can be shown that with a proper selection of orifice diameter to pipe diameter, the error due to assuming the velocity of approach as zero will cancel the error due to assuming a coefficient of discharge of unity. In other words, if we make the orifice diameter from .4 to .6 of the pipe diameter and then use the above equation just as it is, the error will be very small. Where the pressure drop is very large, that is, where the pressure ratio is near to or beyond the critical or where the orifice is placed in a receiver, then the above equation should be multiplied by a coefficient of discharge of about .96.

The above equation gives the quantity of gas flowing in pounds per second. In most cases it is desired to know the volume of gas rather than the weight so by a simple transformation of the given equation, the volume can be found directly. The volume equations are as follows:

For air, $V = .37AK\sqrt{T_1}$
For natural gas, $V = .652AK\sqrt{T_1}$
For blast furnace gas, $V = .361AK\sqrt{T_1}$
For by-product coke oven gas, $V = AK\sqrt{T_1}$

Where V = volume of gas flowing, cubic feet per second.
A = area of orifice, square inches.
K = coefficient from the curves.
T_1 = absolute temperature of the gas on the flow side of the orifice, degrees, F.

The above equations give the volume of gas at the temperature and pressure before passing through the orifice.

The curves for blast furnace and by-product coke oven gas are based on the following volumetric analysis:

Symbol	Blast Furnace Gas	By product Oven Gas
O_2	.....	0.20
CO_2	11.5	2.50
CO	27.5	6.00
C_2H_4	.....	3.30
CH_4	.....	28.50
N_2	60.0	4.50
H_2	1.0	55.00
	100.0	100.00

Additional properties of the two gases are as follows:

	Furnace Gas	Oven Gas
Specific heat at constant pressure	.24	.73
Specific heat at constant volume	.17	.54
Ratio of specific heats	1.39	1.34
Gas constant, R	52.06	143.9
Critical ratio	.53	.54

Mill Designs for Rolling Flat-flanged Beams

Discussing the Method of Rolling Secured in the Puppe Type of Mill, With Gain in Section Shape Secured Thereby—Accurate Adjustment of the Rolls Easily Obtained Through Design.

By F. DENK.

The last mill in the series to be described, i. e., the Puppe mill, differs in many ways from those illustrated in the previous chapters. The mill proper is a universal mill, consisting of two stands, each one having two pairs of rolls. The vertical and the horizontal rolls of each stand are all lying in one vertical plane, the rolls of each pair being equal to each other and symmetrical among themselves.

The main distinction of the Puppe mill in regard to the other types of mills for rolling wide flanged parallel-faced beams is to be found in the method of rolling. In some of the mill types, described before, the flanges are to be developed in a double **Y**-shape, and they are either gradually straightened out, or the beams are rolled down—with double **Y**-shaped flanges—to the final section and these flanges are then straightened out, either in the same stand or in a separate one (see Figures 3 to 6, 9 to 12, 23 and 24), or the flanges are developed flat right from the start as in an ordinary three-high beam mill (see Figures 14, 18 to 21). In the Puppe mill, however, the flanges are bent alternately in a double **Y**-shape and straight.

The beam blank comes from the blooming mill in the shape of a thick walled "**H**." It enters the first or roughing stand, Figure 26, where both web and flanges are worked upon, while the bloom has a double **Y**-shape. From the rougher the bloom is going forward and backward through the finishing mill. In the first pass this mill, i. e., during the forward movement, the flanges are straightened by means of the vertical rolls "**C**" (see Figure 27), while in the second pass, i. e., during the backward movement of the beam through the same rolls, the edges are worked upon at "**D**" (see Figure 28). The beam is then sent again

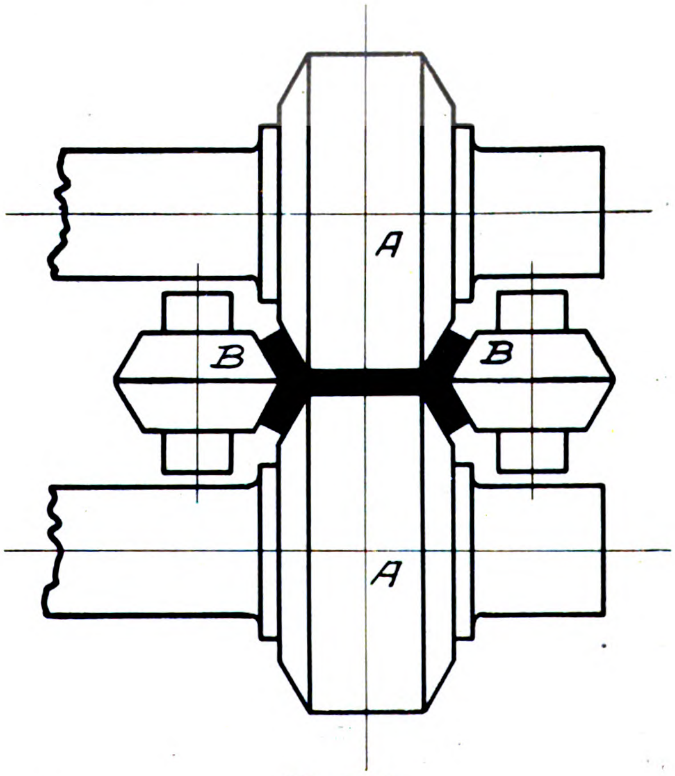


Figure 26.

through the first stand, where the flanges are bent back into the double **Y**-shape. In this way, the beam or girder will be rolled down to its final shape and section by having it go continuously forth and back through the two stands, until the final section is obtained. Through this method, the metal is worked and kneaded more thoroughly than can be done with any one of the other methods; it allows rolling beams and girders with almost any width of the flanges; it furthermore, makes possible the rolling of flanges with absolutely parallel faces. The beams are designed with a slope of 10 per cent between web and flanges, in order to insure a smooth connection between these two parts. This sloped piece, however, is so short in regard to the total width of the flanges, that there is enough space left for the parallel part for attaching, without trouble, by means of rivets or bolts, any kind of cross connection wanted. Another advantage of this type of a mill for rolling wide-flanged beams is the low first cost, which is smaller than that of any one of the other types.

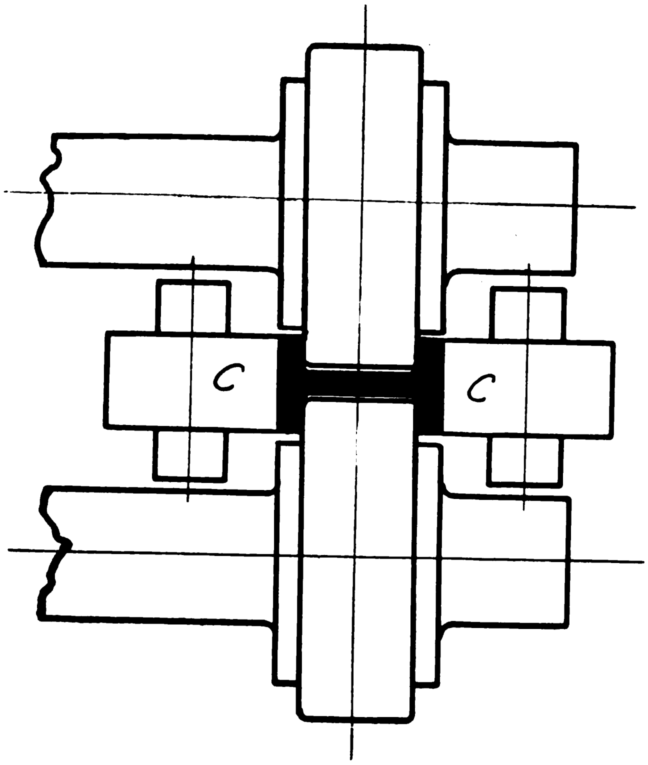


Figure 27.

A general section of a Puppe beam is shown in Figure 29, which represents shape Pb-38, corresponding to a beam about 15″ × 15″. The dimensions are given in millimeters and in inches (the latter ones between brackets; the properties of the beam, shown on the left, are expressed in metric units, while the figures on the right give the same values in the corresponding English units.

Three standard types of shapes, comprising 49 variations, can be rolled in the Puppe mill, as it is arranged to-day. (This refers to **I**- or **H**-beams only. The Puppe mill can also be arranged for rolling channels with wide and parallel-faced flanges.) The smallest size of an **H**-beam rolled is 160 x 160 mm (about 6.4 x 6.4″), the largest one 1,000 x 380 mm. (about 40 x 15″). The beams from 160 mm to 300 mm height (about 6.4 to about 12″) are as wide as they are high; they are the regular **H**-sections. Another group includes all sizes from 300 mm to 1.000 mm (about 12″ to 40″), which have a uniform width of 300 mm (about 12″). The third set comprises the shapes from 320 x 320 mm to 380 x 380 mm (about 12.8 x 12.8″ to 15.2 x 15.2″) and those from 400 mm to 1,000 mm

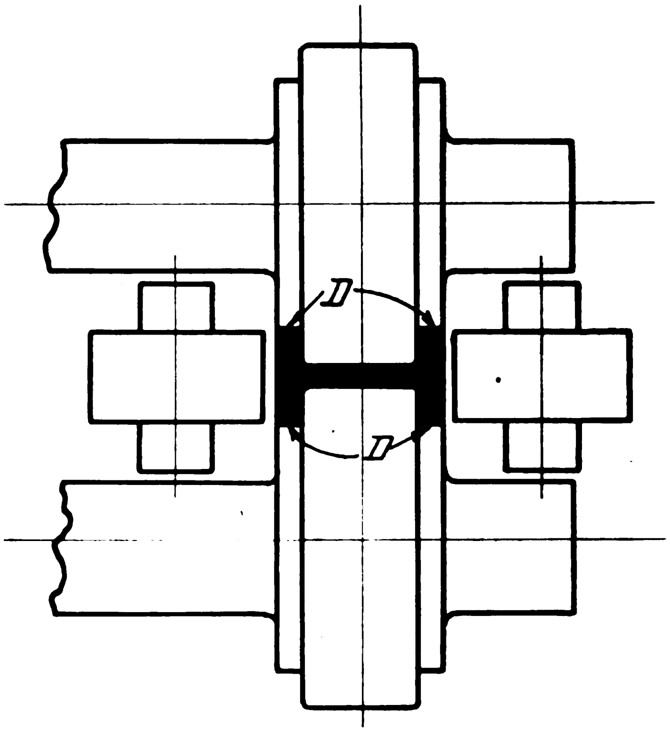


Figure 28.

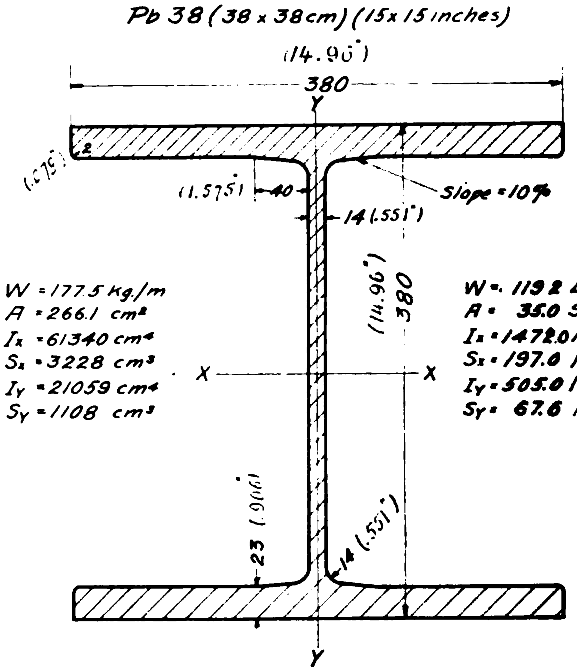


Figure 29.

(about 16" to 40"), having a uniform width of 380 mm (about 15.2"). The equivalents, added above in brackets, are approximations only. For the conversion the value 1" = 25mm has been used instead of the value 1" = 25.4 mm.

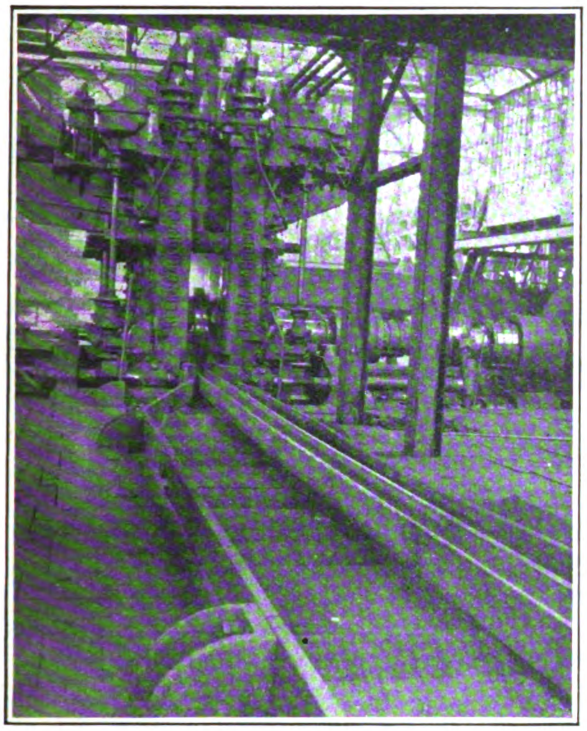


Fig. 30.—Puppe mill, finished beam leaving rolls for cooling bed—Note absence of warping or twisting.

Besides the standard types, enumerated above, shapes can also be rolled with thinner webs, thus insuring a wider variation in sizes, which, therefore, may be rolled to suit any specification.

Since the four rolls in each stand of the Puppe mill lie in the same vertical plane and move relatively to each other during the adjustment between the different passes, the housings and bearings must be designed with the utmost care. This is especially the case in regard to the horizontal and vertical rolls "A" and "B" in the first stand or rougher. The ridges of the rolls "B" must always be exactly in line with the center of the web, since, otherwise, the flanges of the girder or beam would not be rolled with a uniform thickness above and below the web. In order to obtain this condition, Dr. Puppe has invented a simple but ingenious method, which at the same time allows a quick changing of the rolls. By means of this device the vertical rolls are lowered after each pass a distance equal to one-half the amount which the upper horizontal roll is lowered after each pass. This is accomplished by means of a vertical spindle the lower end of which is threaded at a pitch equal to one-half of the pitch at which the upper part is threaded. Now, if this spindle is revolved the upper part will move the horizontal roll exactly twice as far as the vertical rolls are moved by the lower end.

Simplicity of action and a thorough kneading of the material, which includes a thorough working and compressing of the material during the entire rolling operation, not only in the web, but also in the flanges, which, in their outer portions, are subjected to great internal stresses, are claimed to constitute, besides low first cost, remarkable advantages of the Puppe mill in relation to other types of beam mills for flat-flanged rolling.

That the claim in regard to an even distribution of the pressure over the whole section of the beams is justified, may be seen from Figure 30, which shows a photograph of a beam leaving the mill, after being

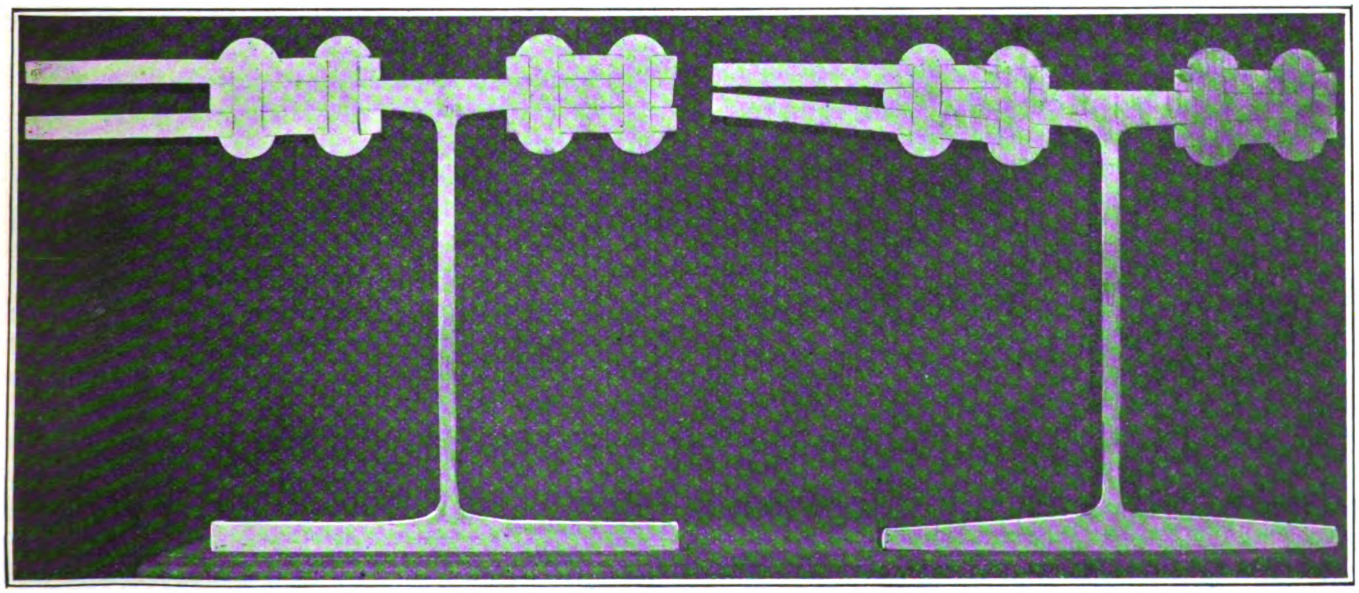


Figure 31.—Puppe and ordinary beams, fitted with riveted-on extensions and sectioned to show the practical parallelism in the former type.

rolled down to its final size. The photograph was taken while the mill was working. It shows that the finished beam leaves the last pass in a perfectly straight condition. A straightening out of the cooled beam is, therefore, unnecessary, because the setting up of internal stresses is avoided, which, under certain conditions, may render the beam useless for commercial purposes.

The advantage of parallel-faced flanges (for instance Sack or Puppe sections) over those with a uniform slope can be seen from Figure 31, which is a photograph of connections made with Puppe beams and with Differdingen Grey beams. (These Differdingen Grey beams have a uniform slope of 9 per cent, and for this reason, the convergency is avoided to a large extent with the Bethlehem Grey beams, which have a slope of only 2 per cent).

One Puppe mill is in successful operation since the end of July, 1914, in Peine, Germany, and has, up to the present time, never shown any defects, neither in the construction or the design of the mill, nor in the calibration of the rolls.

Gearing Development through Treatment

Showing How the Development of Heat-Treating as Perfected for Automobile Gears, Can Add Inestimably to the Life and Service of Rolling Mill Gear Trains and Increase Efficiency.

By **W. H. PHILLIPS.**

The automobile, more than any other one factor, has been responsible for the advance in heat-treatment technique, but there are many other manufacturing lines which are profiting from the betterment secured through the agency of the motor car. In the rolling mill, for instance, proper heat-treatment will add much to the life of table gear drives, reduction gears between motor and driven unit, on cranes and in the many other steel mill applications of the as a method for transmitting power.

If by increasing the cost of gearing from 25 per cent to 50 per cent, a gear is produced that will triple the life of the untreated steel gear and at the same time eliminate breakage with its consequential damage, there can be no doubt of its economy. A few of the advantages to be derived by such a step are:

1.—Lower ultimate cost of gearing.
2.—Reduction of time loss.
3.—Reduction of labor maintenance.
4.—Reliability.

For example: the untreated gear costs $10, and runs for one year. The treated gear costs $15, and runs three years. This would show a saving of $15 on initial cost. If it requires two hours to make replacement, it would require six hours to replace the $10 gear three times, and but two hours to replace the $15 gear, or four hours saved in labor, also four hours saved in production of the machine. The hazard of breakage with its consequences is an unknown factor, but may be serious in some services.

If it is true that there is an economy in the use of heat-treated gearing, the question naturally arises as to what is the proper grade for different conditions. This is a matter that should be given careful consideration, lest the wrong application is made and the results are unsatisfactory.

Except where weight and space are important, alloy steel gearing is not commercially practical, due to its high cost. In the automobile field, where a comparatively small gear tooth must stand great strains, the strength and toughness resulting from alloying certain elements, such as chrome vanadium and nickel with steel, are very desirable, if not absolutely necessary. But this covers a comparatively small area of the gear field and for the most part, heat treated carbon steel gearing is meeting every requirement imposed upon it and still has a great field for development.

Heat-treated carbon steel gearing may be divided into three general classes:

First—Oil treatment.
Second—Case hardening.
Third—Special treatment.

The first two classes mentioned were introduced in the above sequence and have met many problems. Each has its advantage for different services and in this service has proved very efficient. There are conditions encountered, however, in which these two grades are not applicable. The third grade mentioned has been developed after a careful study of actual conditions and embodies the best qualities found in both former grades.

There are applications where the service is so light that the resultant long life and low maintenance cost do not recommend a high grade product. There are other services where the gear must transmit a uniformly high torque without sudden jars or dynamic blows, in which case it is a question of wear alone, requiring such surface hardness as found in the case-hardened product. There are other applications where the load to be transmitted is uniformly low, but with occasional shocks. This transmitted is uniformly low, but with occasional shocks. This last-named condition requires a gear with only medium hardness, but with high ductility such as the first-class or oil-treated gear. There are installations, and these are in the majority, where the service imposes both the heavy duty with its resultant wear, as well as shocks with the liability of breakage. It is for such service that the third-class or special grades have been developed. By analyzing the conditions and selecting the proper grade, it will be possible to obtain the best results.

Before considering the three classes of gearing, comparing and explaining the properties of each, it will be well to explain briefly how gearing is manufactured to insure equality and uniformity of product.

The old-fashioned eye pyrometer and rule-of-thumb methods of heat-treatment, used a few years back have given place to the modern treating department, with its closely-regulated furnaces and accurate temperature-recording instruments. Poor heat treatment is worse than no treatment at all, often leaving the steel coarse-grained and brittle. The laboratory which must be maintained in conjunction with the treating department, gives the exact analysis of the gear to be treated. To-day, knowing the chemistry, the method of procedure becomes an exact science with the uncertainty and doubts removed.

One or more gears in every lot of 100 should be taken for physical test, the test, when size permits, being taken from the root of the tooth. This test should conform to the A. S. T. M. standard of 2 in. pulling test, giving tensile strength, yield point, elongation and reduction. This testing of one gear in every lot of a hundred or fraction of a hundred, does not necessarily insure uniformity. There may be one or more gears that have failed, due to one cause or another, to come up to the required standard. As a check on each gear the Brinnell hardness test may be used, the advantage of this method being that it does not deface the gear to any extent, yet is thorough and reliable. Briefly, it consists in pressing a 10-millimeter ball into a flat surface of the steel at a constant pressure of 3,000 kilograms and measuring the diameter of the impression with a scale magnified and graduated to one-twentieth of a millimeter. As a result of many thousands of these tests, a good working knowledge of the tensile strength of the steel can be obtained. By the Brinnell method each gear is tested on opposite sides of the periphery, knowing what the hardness should be within a certain range, and rejecting when the test falls above or below this range, a high uniformity may be obtained. This is the most reliable, practical and widely-used hardness test known, all variables except the hardness of the steel itself being eliminated. Therefore when a gear has been analyzed, properly treated and tested, its conformance to the required specifications can be depended upon.

The oil treatment was the first method used for hardening and toughening gearing. The method consists in heating the steel to the required temperature and quenching in oil. This treatment is not severe and does not set up heavy strains in the steel. The ductility is high, but the hardness only slightly greater than that of untreated steel, as is also the strength. Where it is desirable to increase the hardness and strength somewhat and retain a high ductility, or in other words when the gearing is subjected to shocks and ductility is important, an oil-treated gear may be advisable. The increased cost of this grade over the untreated grade is not high, and this may be worthy of consideration. As shown by the Brinnell test, the hardness is increased about 75 per cent. While this may seem to be a very material increase compared with the other two classes mentioned, it is relatively small. The oil treatment may be applied to forged or cast steel gears.

The case-hardening process consists essentially of a high-carbon case, backed up by a low-carbon core. A low-carbon steel is used, introducing the high-carbon case by the treatment. The depth of this case can be controlled by giving any penetration desired. This treatment has been known for a long time, but it has been applied to gearing only in recent years. Comparing the hardness of the case and core with that of untreated steel, the case is found to be four times as hard as untreated steel, while the core is only slightly, if any, harder than the untreated steel. When the service is such that heavy shocks do not occur and all the gear need do is transmit uniform load, the very hard case of this product resists wear well, and the gear will give a long life. When, however, the load to be transmitted is variable and there is liability of heavy shocks the case will get this strain first and being very brittle will tend to fail. This treatment is somewhat more expensive than other grades as it requires at least five applications of heat to properly harden a gear. Care must be exercised in handling and installing this gear, as the case will be spalled off by a light blow. It is desirable, also, in order to secure maximum life, that it be run in both directions to utilize the benefit of the case on both sides of the tooth.

With the ever-increasing knowledge of steel and its heat-treatment, being accumulated year by year, the above two grades were improved gradually until now they have been perfected as far as possible and the metallurgist for some time has been looking to other fields for a grade that would include the good qualities of both the above grades, yet supplying what they lacked, and, if possible, reducing the cost of the heat-treatment. As stated before, the alloy steel had to be eliminated, due to its cost, and the only course left was to develop a treatment for carbon steel that would give the required results. Several of these so-called special grades were introduced, one of the more notable being the BP grade, manufactured by the R. D. Nuttall Company, of Pittsburgh, It was found that by slight changes in chemistry a combination could be obtained which, when subjected to a special treatment, produces physical properties peculiarly adapted to gearing. The hardness at the surface of the steel is from three to four times that of untreated steel, and grades off slightly toward the center of the tooth until it is from two and one-half to three times as hard as untreated steel. This reduction in hardness is in a straight line ratio and each fibre of the steel from the surface to the center, or neutral axis of the tooth, which may be slightly to one side of the geometric center, will be stressed in proportion to its ability to carry the load. So that, when the tooth receives a blow or shock every fibre is carrying its share of the load. The ductility of this steel is comparatively high and is in inverse ratio to the strength. The metal is homogeneous, there being no line of demarcation between any two fibres. While the surface of the tooth is hard, yet it is of a tough hardness and will not check or spall. It is often advisable to treat the pinion only of a combination, it being the weaker and harder-worked member. A pinion so treated, due to the nature of the hardness is not liable to cause excessive wear on the meshing untreated gear. It can be readily seen that a gear of this type which is of moderate price, will have a great tendency to overcome breakage and at the same time give a high resistance to wear. It should triple the life of untreated gearing, and eliminate the cost of consequential damage and delays caused by gear breakage.

Often gears are designed with no intention of ever being heat-treated, and may be so flimsy in certain sections that it would be impossible to submit them to the strains necessary in heat treatment. These gears, however, are intended for light service and usually give no trouble if untreated.

The effect of dynamic blows on spur gearing when running at high speed and transmitting heavy loads, while it has never been accurately ascertained, is known to be great, often excessive, and in such service, wherever possible, forged steel should always be used.

The wide application of the heat-treated gear not only in the railway and automobile field, but also in many branches of the industrial field, among the more notable being the steel mills, foundries, glass plants and mines, has been so successful that it is not a question of heat-treated vs. untreated gearing, but rather the selection of the proper grade of treated gear for the service to be performed.

In conclusion, it might be said that with many industries of the country working over capacity, the necessity for reliability of machine parts was never before so desirable or the consequences of breakdown so costly. A careful study of the gear situation in the plant or mine should be made this time and any changes insuring this reliability, acted upon at once.

"Piping-Hot!"

The Hot-Blast Considered in Art.—A Diletani Digression.

To the Editor, **The Blast Furnace and Steel Plant:**

Whatever may be one's opinions of the hun-thug hordes of Central Europe,—giv them credit as iron-workers—and artists!

"Piping Hot!"—A celebrated deutsch (hun) painting of the rolling of a white-hot ingot at Krupp's.

Here's a reproduction of the celebrated painting by Adolf Menzel in the public gallery at Berlin, showing a white-hot ingot being rolled at Krupp's, Essen. Writer is familiar with both places—as also with (for that matter) most of the great hot-blast centers of the universe, and even down to the petty katalan forges of the Pyrenees; the iron-working shacks of the Ganges; and the primitiv plants of cold-blast Cibipia (Cibiria); and also those or the Sierras of Mexico; the pampas of Argentina; and the progressiv plants of the Antipodes. However, that's " 'nother stori."

* * * * *

When the isitor comes suddenly on to that painting in the museum, he instinctivly wud draw back,—such is the relisticness of the white heat casting in the tablo!

Of course, it is only one of many such scenes going on simultaneously all over the Krupp works—'special-ly just now!

* * * * *

Study the figures in it—the glare, the glamor—(you can almost hear the crunching rolling of the mills!)—, the realistically-natured attitude and poises of the workers at their sweating toil; the reflections from the white-heat;—the light-and-shade effects; the hurried "sneek" or "bite" being taken by the employes to the right:—the bit of leather-skreen to shield one from the heat; and, to the left, a shift washing-up ere "homeward they wend their weary way"; and the remainder of the forest of rushing belting and thunderous rolling-mills lost in the smoke haze and distance.

A more vivid, emotional painting of factory-life has never been made in iron-workingdom!

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The facial-castes of the employes ar all distinctly hun'ish.

Down the left aisle, in the distance, can be seen the silhouet of the artist, "sizing up things." For the deutsch genre painter Adolf Menzel was, like Bepacharin (pronounced Berachagin), noted for his teknique-familiarity.

* * * * *

This fotograf was made direct from the painting. Exposure: 1 hour. But ther ar a couple of different-sized rich engravings also existant of the painting, and these the tourist may observe in some print-shops in the continental cities; also in the homes and private offices of iron and steel magnates, and even in the buros and chatlets of the galik maitre-de-forges. For, when it comes to art, your gavlois ironmaster knows how to appreciat, and will hav it, be it deutsch or persian, sanskirt or ianki!

* * * * *

By way of semi-humorous, sarkastik contrast, let me add, I showed the fotograf to a couple of Manhattan iron-trade journal "redaktors." "Throw pearls to swine"! They didn't see the least interest or merit in it! "It's only what you can see any day in our mills and foundries." The fact that it was are putting vivid life-and-toil on to lifeless canvas, did not appeal to them!

Slaves to mere quick-lunch money-hustling, and their lapdog-and-siringe wives!

As old Dana wud hav said in emfatic classical American,—"bloody fools!"

L. Lodian.

Silica as a Component of Furnace Slags

Slag Characteristics Due to Silica; Relation to the Driving of the Furnace; Its Effect Upon Sulphur and Other Slag Components; Relation of Silica to Slag Volume and Hearth Temperature.

By WALLACE G. IMHOFF.

It hardly seems necessary to discuss such an ordinary component of slags as silica, yet it plays an extremely important role in determining the characteristics of slags. It is determined in all slag analyses and is represented by this chemical formula, SiO_2.

Aside from this part that it plays in blast furnace slags some of the following characteristics may be worth remembering. Pure silica, according to Clark in his "Data of Geochemistry" melts at 1,775 deg. C. (Robert Austin) and 1,685 deg. C. (Hempel). It draws a thread when fluid which on cooling is very brittle and easily broken. In appearance it generally has a glassy or vitreous look although in sand it is dull.

Returning to the discussion of slags we find the above characteristics prominent. Silica at all times gives slags their vitreous appearance. On the one hand extremely lean slags have a glassy look and as the amount of silica decreases in proportion to the bases, the slag changes from a glassy appearance to a vitreous lustre, thence to a dull stony appearance and finally this disappears entirely when the bases have become so large that the fracture is grainy or powdered in appearance.

Slags having a large amount of silica in them will always draw a thread from the test spoon. In the sample they are extremely brittle, like glass, and generally depreciate on cooling. A lean slag will often show a deep curved sag in the top of the test sample and is usually dense and solid, due to the fact that any gas has been able to easily escape.

Some of the following peculiarities may be seen in slags high in silica in the molten state. They generally are very fluid and run very fast from the furnace. Usually they are accompanied by an extremely strong odor of sulphur, which seems to rise from the slag as a thin blue smoke. Even after this type of slag has filled the ladle this blue smoke continues to rise from it. The smell is sometimes unbearable and not only is choking, but also makes the eyes burn and smart.

When in the molten state slags high in silica have a glassy, watery look and a glistening, shiny surface. Small rings, or eyes keep spreading over the surface and any gas held in solution escapes much the same as gas or air bubbling up through water.

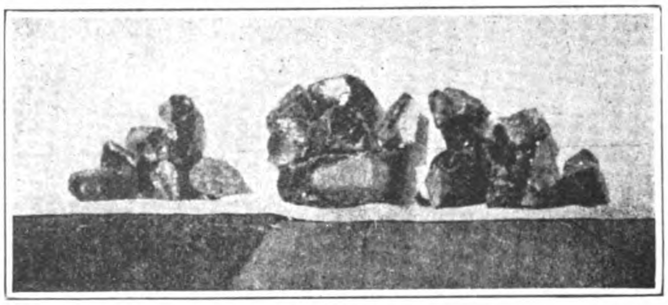


Fig. 1.—Slag high in silica. Note the hard glassy appearance of the fracture. The brittleness has caused them to break into many pieces on cooling due to contraction.

On cooling the sample will show an extremely glistening, glassy surface if the slag is hot, but a dull, glassy surface if cold and may be colored brown, due to manganese. Very hot lean slags are generally some shade of deep bottle green, but change to a dark olive green and blackish green to brown when they are cold.

When coming in contact with water, hot lean slags become extremely light and fluffy and lose their glassy appearance. They then take on the appearance of extremely fine sand and become grainy when crushed between the fingers.

A slag sample when lean will have a tendency to contract and will drop very easily out of the sample box. A limey sample will often stick very tight and is removed with difficulty. Glass slags seldom carry any iron shot in them. The more silica a slag carries the smaller will be the cinder remainder after the slag has been run off.

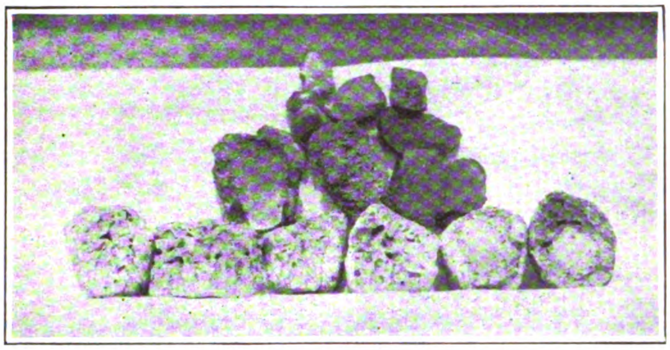


Fig. 2.—Slags low in silica. Note the dry, grainy appearance of the fracture.

The element silicon and its oxide are one of the most important factors in blast furnacing. With a thorough knowledge of the properties of silica and lime the operation of the furnaces becomes much more smooth and regular for the other components are relatively unimportant. It has been commonly said "lime fluxes the silica," but the reverse is really what takes place, the silica fluxes the lime and due to its much lower melting point and fluidity carries it out of the furnace. When a furnace has been too heavily limed, sand, or silica in the form of heating cinder, is put in to cut it out, or extra coke to give additional heat and silica both.

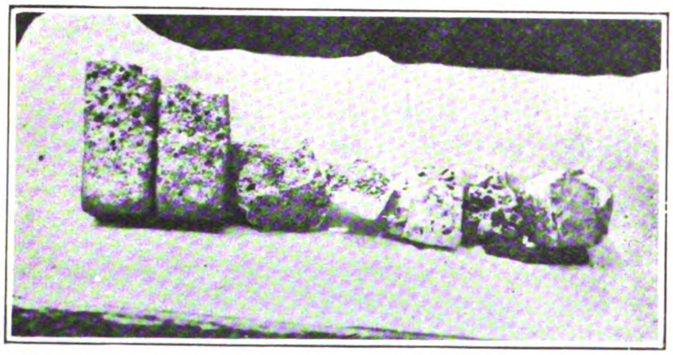


Fig. 3.—Foundry iron and slag. Low silica in slag, therefore tendency to be dry and glassy.

In discussing silica as a slag component it seems in place to discuss slags which cut out the furnace lining. There are two kinds of slags which attack the silica brick of the lining, first a cold lime silicate slag, and second, a thin, glassy black iron silicate slag.

The prime factor which determines whether the silica shall be in the iron or in the slag is the hearth temperature. A cold hearth will always favor the silicon going into the slag, therefore if a large amount of lime is present such as may occur in making basic iron, the burden may not furnish enough silica to combine with the lime. The temperature being low the lime simply attacks the silica brick and fluxes it, cutting away the lining. The writer saw one lining cut through in five months on a newly-lined furnace by this kind of a slag. The way to overcome this condition is to take off lime and increase the hearth temperature by any of the means available. This puts the silicon into the iron and raises the hearth temperature above that which will cut the lining. Obviously a few high silicon casts must be made to do this before the furnace can again be put on basic iron. These lime silica slags are entirely creamy white and represent a very low hearth temperature and large slag volume.

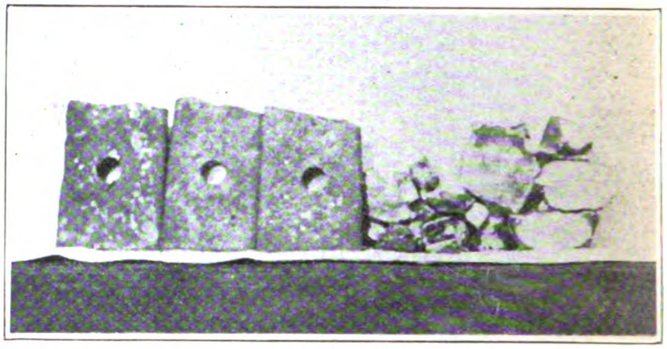
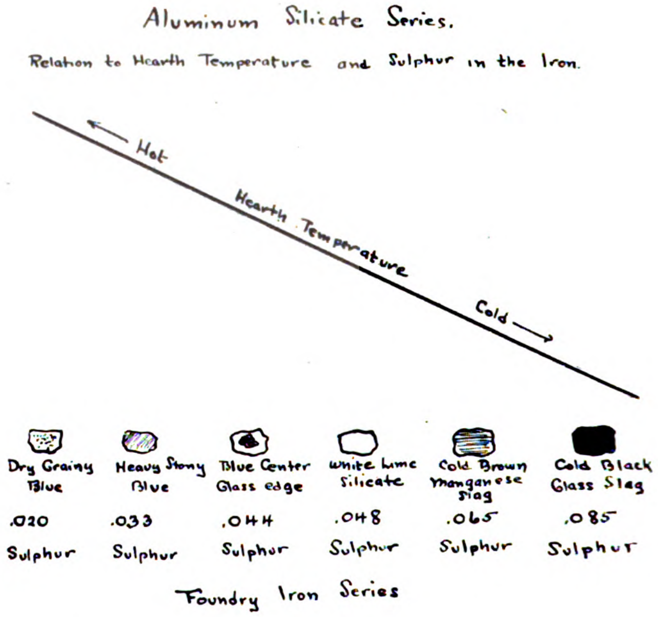


Fig. 4.—Basic iron and slag. High silica in slag, therefore tendency toward vitreous or glassy state.



The second kind of slag which wil cut out the furnace lining is an iron silicate slag. The hearth temperature in this instance is also extremely cold, in fact this type of slag has been termed by furnace men as a "Scouring Slag," since most of them know such a slag has a cutting action upon the lining.

The conditions present which produce this slag, and the cause of its cutting the lining are, the bottom is so cold that the iron is oxidized to iron oxide and this lower oxide of iron immediately attacks the silica of the brick in the furnace lining forming iron silicate. Iron silicate slag is, therefore, the second type of slag which destroys the lining.

To overcome this condition the first thing to remedy conditions is to supply heat to the bottom. This will overcome the oxidation of the iron to the lower oxide of iron which will in turn stop the fluxing of the silica in the lining.

Any of the above facts may be proved by simply making the slag described and watching the results.

The effects of silica on the driving of the furnace is illustrated by Figure 1. The lime and alumina remained constant and the burden was increased. The first slag was a dry blue grainy slag and the furnace was hot. Fifty pounds of ore were put on the burden with the result that the furnace started to drive faster, and since the coke remained the same, the furnace began to grow colder; the tonnage also increased with the next cast. The increase in silica in the slag is shown by its changing from a dry blue to a strong blue cinder.

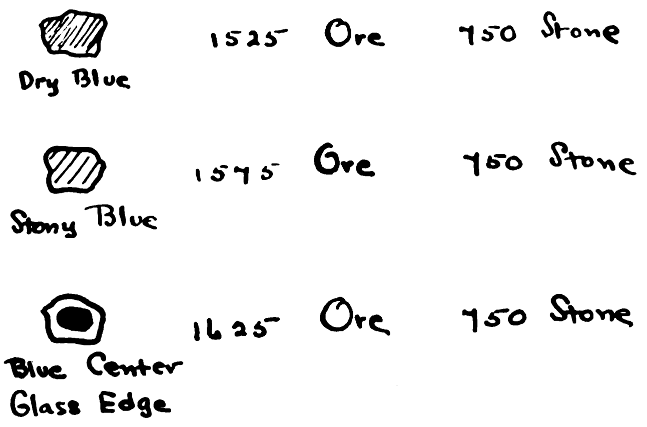
Fifty pounds more ore was put on the burden, the lime and alumina still remaining constant. The effect was to make the furnace drive still faster. No extra coke was put in and therefore the conditions seen by many furnacemen were present, the furnace was driving itself cold. The additional silica in the slag is now seen by the glass edges. The lime has now become short and we see a blue aluminum silicate center to the slag. The tonnage has increased rapidly, the furnace has driven itself cold, the sulphur has risen in the iron and the charge begins to stick and hang and slipping starts.

The effect of hearth temperature as influencing silica in slags and sulphur in irons is shown by Figure two. With foundry irons the hearth temperature is high, at least if low sulphur iron is being made. This drives the silicon into the iron and the slag shows the lack of it by its dry grainy appearance. As the temperature is lowered more silica goes into the slag and the slag becomes a heavy blue stony type. With still further drop of hearth temperature the silica in the slag is seen by the glass edges and finally the temperature has become low enough to form the cream white vitreous lime silicate. With still further lowering of hearth temperature the slag becomes cold and shows the manganese brown color. Finally, when the hearth becomes extremely cold it turns to the last cold black glassy type.

In regard to the sulphur in the iron we first note how sulphur for the silicon is in the iron and therefore the lime present forms a high lime silicate and takes care of sulphur. As the temperature is lowered the silica begins to increase in the slag. This requires lime and forms a lower silicate which melts at a lower temperature and is more fusible. But the silica has taken the lime from the sulphur as seen by the rise of 13 points.

Still further drop of temperature sends more silicon to the slag less SiO_2 is reduced which increases the silica and this in turn takes more lime from the sulphur with the result of a further rise of sulphur in the iron. The series of Figure 2 shows the rise of sulphur in the iron from .020 to .085 due to a lowering of the hearth temperature with the result that the lime was taken by the silica formed and the sulphur left free to enter the iron.

Slags – Lime and Alumina Constant.



Percentage Change of Analysis.

Silica	30.18	30.58	33.02
Alumina	17.44	17.22	15.70
Bases	49.07	48.88	48.51

The above series automatically would actually increase the slag volume. Hearth temperature is a direct factor in controlling slag volume and the actual quantity of slag produced will be partly controlled by the hearth temperature. The actual freeing of the sulphur with the decrease of hearth temperature may be noted by the change of fog from the cinder when running. On very hot foundry irons this smoke is a heavy white rolling smoke which may be breathed in without any harm. As the sulphur is freed by the increase of silica in the slag the smoke turns to a thin blue and is choking and suffocating to breathe. It also burns and makes the eyes smart severely and if long exposed to it they will become red and bloodshot.

No matter how the mix of the burden is figured the hearth temperature controls the final product of iron and slag. Often a rise of sulphur is caused on a bold bottom by too much lime rather than not enough. Still more lime is put on to take care of the sulphur with the result that the furnace goes off and gives considerable trouble. Such conditions affect the silica in the following manner: The low temperature of hearth sends the silica to the slag. This leaves the sulphur free to go into the iron. An addition of lime further to the burden lowers the hearth temperature still more when it comes down because it takes heat to melt lime. The still lower temperature takes more silica to the slag with the result of still further rise of sulphur in the iron. The conditions of a cold bottom and too much lime are directly represented by the continued drop of silicon in the iron with a corresponding rise of sulphur.

The following actual case illustrates the above discussion:

Silicon	Sulphur
1.02	.022
.97	.036
.77	.036
.66	.039
.29	.062
.17	.085

Therefore to overcome this condition the very first thing to do is to take off considerable lime. This gives the silica a chance to go into the iron and this is accompanied by a rise of hearth temperature. Removal of lime and heat to the bottom at once will remedy the above conditions.

An extreme rise of sulphur and drop of silicon in the iron is often caused by the opposite reason a shortage of lime and a very large excess of silica in the slag. This is brought out by the following iron and cinder analysis:

Iron	Sulphur
.04	.281
.13	.211
Cinder.	
High silica	38.00
For alumina	9.94
Sulphur	.....
Low lime	46.69
Magnesia	.....
Iron	.....

The effect of cold air on silica in slags is also interesting. At times cold air is run into a furnace all day with the result that at night the furnace gets beyond control and continues to go cold. It is evident the cause of the trouble has been that the heat was not started up soon enough. It takes time to slow a furnace down and also time to start it back, therefore this should be allowed for in rapidly heating or cooling the hearth. The following analysis shows the effect of not starting the heat up soon enough after running cold air into the furnace all day:

Silicon	Sulphur
1.05	.024
.58	.043
.29	.079

Another case of the same kind:

Silicon	Sulphur
1.90	.032
1.32	.041
.38	.085

Continued use of cold air, therefore, has the effect of sending the silicon to the slag and raising the sulphur in the iron. This again illustrates the fact that slag volume is a function of the hearth temperature.

The striking features of controlling the silica in the slag is now evident, raising or lowering the silica in the slag is accomplished by the regulation of the hearth temperature.

Early Iron Maker.

One of the fascinating stories of American business, is the spectacular development of steel. But very little attention is given to the little grey pigs of iron that are the foundation for the vast industry. In its March issue "The Nation's Business," tells the Iliad of pig iron in a story about Samuel Croxton, of Cleveland.

Mr. Croxton has been making pig iron for fifty-one years.

He is still making it. Besides playing a heroic part in the development of the industry, he was associated with some of the colossal figures who saw the greater future in our immense ore stores.

Mr. Croxton is more than a "typical iron-maker"—he is, perhaps, in age and achievements the pig iron-maker of the United States. Plenty of men made pig iron before he did, but all of them are dead. Carnegie and Phipps were manufacturers of steel. Frick, after leaving his grandfather's store and distillery, went into coke. Schwab was three years old when Croxton, back from the Civil War, began as a shipping clerk at the Ohio blast furnace of Daniel P. Rhodes, who, only the year before had become Mark Hanna's father-in-law.

It was Rhodes who persuaded Mark Hanna to quit refining oil and engage in some enterprise that wouldn't catch fire and burn down in thirty minutes. If Hanna had stuck to petroleum he might have become as rich as John D. Rockefeller.

When the Civil War came along and began kiting prices of iron, Rhodes had a hankering to own a furnace. Mr. Croxton says:

"So he and his partners bought the Dover furnace early in 1865 for $40,000. They had also purchased 600 acres of ore, limestone and coking coal lands for $20,000.

"Their investment, accordingly, was $60,000. They organized a company, turning over to it the furnace and lands, along with some cash, and other ore and coal land for which they received $500,000 in stock. Rhodes and his partners expected to pay 6 per cent dividends regularly and make the stock worth its face value in the near future.

"There may have been previous examples of what was afterward known as high finance, or the capitalization of prospective earning capacity, freely guessed at, but none has ever come to my notice.

"The industry," continued Mr. Croxton, "has been periodically profitable for sixty years. Boom times in pig iron began in 1855, 1864, 1872, 1881, 1892 and 1899. Between those dates, however, owners of furnaces had some terribly bitter experiences. From 1907 to 1915, and including both years, the pig-iron business could not have been worse. It was halted by the panis that occurred in the former year and did not recover its step until the breaking out of the war in Europe."

Refractory Linings and Materials No. I

In Which the Author Will Take Up, Seriatim, the Refractories Used in Steel Plants, Showing the Methods for Obtaining Best Results at Each Point Where Used.

By J. W. HAULMAN.

Lining of Iron Ladles.

The writer has been connected with a steel plant for many years and has given the refractory linings and materials in such work special study. These applications and materials are among one of the most essential parts of the operation of a plant and mean a great deal to successful operation and constitute a large percentage of the operating costs connected with the handling and working of direct blast furnace iron. These researches have covered the lining of iron and steel ladles, iron cupolas, calcining kilns, converters, open hearth furnaces, etc. A lining which will not resist the ferrostatic pressure and the reactions that take place in any vessel containing molten metal will not only cause a loss in the lining, but a loss in product and require labor to remove the scrap produced, and all loss of metal in handling, which must be converted over again, consequently must withstand a loss the second time to a more or less extent.

Before going into the applications of linings it will be well to consider the chemistry and qualities of the materials used in linings, the main ones being clay brick used in resisting the temperatures and abrasive action of slags, etc.

The brick used in the lining of iron ladles, which should be of a good quality of fire brick, can be well protected if a proper lining is put over them, and thus prolong the life of the brick lining for a long period of time.

The first part of refractory work in a steel department begins with the lining of ladles used in transporting the molten metal from the blast furnaces to a metal mixer and from there to the Bessemer converters or to open hearth furnaces. This lining is about the least affected of any, owing to the fact that the metal is colder now than after it has undergone a transformation, and there are no reactions taking place in this ladle.

A practical lining for such ladles that has given excellent results is a single fire brick lining against the iron work or "shell" of the ladle, and on top of this flat course of brick is rammed a mud cake lining which can be easily and cheaply prepared. The formula for a mud cake lining calls for six parts of crushed fire clay brick bats, two parts of a clay that may be found in almost any locality, and ten shovels of a silica stone, ground together in a mixing pan, with enough water added to make it plastic. In the selection of a clay care must be taken to get one as low in fluxing impurities as possible. The kind that should be used for this purpose is a tough plastic clay, usually found in low lands and swamps. It should analyze as follows: SiO_2, 54.00 per cent; Al_2O_3, 30.00 to 32.00 per cent; combined water (H_2O), 10.00 to 12.00 per cent, with a small percentage of $Fe2O_3$, which should not exceed 3.00 to 4.00 per cent. The clay must contain elements of a high melting point, as the temperature of blast furnace iron running into the ladle is about 2,860 deg. F., and the lining of such a ladle must consequently be of a higher melting point, therefore, it is essential to have as high a percentage of Al_2O_3 in the lining as possible, as this has a melting point of 3,670 deg. F. After preparing this mixture in a grinding pan it is thrown on a board and rammed into a solid mass and then cut into cakes of convenient size to handle, and then placed in the ladle next to the brick work and rammed down to a smooth, solid surface and very thoroughly dried before being put into service.

Such a lining will last in an iron ladle about 48 hours' constant use, or until it is so badly skulled that it is unfit for use, after which the ladle is cooled and the "skull" is easily removed by cutting around the edges and when the ladle is turned upside down it will drop out, taking the inexpensive mud cake lining with it, without any injury to the brick work underneath, which serves its insulating purposes without loss.

Discussing Patents, Copyrights, et cetera

To the Editor, **The Blast Furnace and Steel Plant:**

Some time ago a reader of your magazine wrote me, asking me to secure a copyright on his trade-mark. I have had the same inquiry any number of times. In view of the error, which is an excusable one, I wish to broadly point out the differences between trade-marks, copyrights, design patents and mechanical patents.

A trade-mark may be registered by filing an application in the United States patent office. A trade-mark is a peculiar distinguishing mark or device affixed by a manufacturer or merchant to his goods. It is a commercial signature and the purpose of the trade-mark is to guarantee the genuineness of the product. The term of the registration of the trade-mark is twenty years, the government fee $10, and the mark may be renewed. If anticipated, registration is, of course, refused.

A copyright is recorded without a search in the copyright division of the Library of Congress. The fee is nominal, or $1, and the term is twenty-eight years.

A design patent is secured by filing an application in the patent office for a new and ornamental design. To secure a design patent, invention must be involved, while this is not essential to the validity of a copyright or trade-mark. If not anticipated, the inventor secures a design patent for a period of three and one-half years, seven or fifteen years upon the payment of a government fee of $10, $15 or $30, respectively. A "mechanical" patent may be procured by filing an application in the patent office for any new and useful art, machine, manufacture or composition of matter, or improvement thereof. Invention must be involved. Patent is issued for a term of 17 years and the government fees are $35.

A print is a device used for advertising purposes and is not attached to the goods, while a label is a device to designate the contents of a product to which it is attached. Both are recorded without search in the patent office upon a government fee of $6.

It is highly advisable that the services of a skilled patent attorney should be retained to secure protection of these very valuable pieces of personal property. For instance, vast property rights are based on trade-marks. It is said that each letter in the word "Uneeda" is worth a million dollars and the value of such trade-marks as "coca-cola," "Royal" baking powder, "Sapolio," "Bon Ami," "Kodak," "His Master's Voice," with the symbol of a dog, and many others, are well known. The rivalry of competing manufacturers is so keen, the value of a trade-mark is so great and because the practice of registering a trade-mark in the patent office is so technical, it is always advisable to secure the services of a competent attorney.

The writer, before entering the practice of patent and trade-mark laws, was an assistant examiner of patents and an assistant examiner of trade-marks in the United States patent office. There, many hundreds of applications, both trade-mark and patent, were examined by me and I can say that in a great majority of cases, the applicants were represented by attorneys. Those cases wherein the applicant prosecuted his own case often became hopelessly confused and his entire rights were jeopardized. The old adage that "He who is his own attorney has a fool for a client," was never more applicable than in trade-mark and patent cases.

I trust that this discussion will be helpful.

Norman T. Whitaker.

Personal Mention.

H. H. Roberts has been made chief engineer for the LaBelle Iron Works, Steubenville, vice William Forsstrom, resigned.

V V

V. J. Passetti has become night open hearth superintendent for the Bethlehem Steel Company, South Bethlehem, Pa.

V V

Edward N. Rich is now president of the Alabama Company, Birmingham, Ala., effective April 1, succeeding J. W. Middendorf, formerly at the head of the company while it was known as the Alabama Coal & Iron Company.

V V

C. C. Rice is now superintendent of the Deforest Sheet & Tin Plate Company, Niles, Ohio. He has been with the American Steel & Tin Plate Company, at Dover, Ohio, for the past twenty years, resigning his position there to take up his new work.

V V

Carl W. Pierce, superintendent of open hearths for the Central Steel Company, Massillon, Ohio, has resigned to accept the position of open hearth superintendent for the Cromwell Steel Company, Lorain, Ohio.

V V

Howard Wood, Jr., assistant secretary of the J. Wood & Brothers Company, Conshohocken, Pa., has been made manager of that plant, now that it is a part of the Alan Wood Iron & Steel Company, also of Conshohocken.

A Correction.

In the article "Mill Design for Rolling Flat-flanged Beams," on pages 101 and 102, figure numbers should be, for page 101, Figures 18, 19 and 21, and on page 102 Figure 20 should be under the cut shown as Figure 18.

Roll Scale as a Factor in Bessemerizing

Use of Otherwise Waste Product in Facilitating Control of Pig Iron Refinement in the Converter—Mill Records to Show Effect of Varying Additions to Blow—Effect of Moist Scale.

By A. PATTON and F. N. SPELLER.

The use of roll scale in the Bessemer process dates back, to the best of our knowledge, at least 20 years. It was first used by the Ohio Steel Company, Youngstown, Ohio (now the Ohio Works of the Carnegie Steel Company) under direction of Sam MacDonald, Superintendent of the Bessemer Department at these works. Two 10-ton vessels and one blowing engine capable of blowing one heat at a time were employed. The object of using the scale was to shorten the length of the blow, or in other words, to increase the production with the same equipment. Various means were tried out for introducing the roll scale into the bath of molten iron: It was shoveled into the vessel before the heat was charged, so that the metal would flow over the scale; it was shoveled into the bath after the vessel was turned up; it was dumped into the empty iron ladle by the wheelbarrow-load, and at times was dumped on top of the molten metal in the iron ladle. But the practice of introducing the scale into the iron ladle had to be abandoned on account of danger from explosions and of skulling the ladles. It was soon learned that the proper place to charge the scale was in the empty vessel, so that when the molten iron was poured into the vessel it flowed over the scale, causing a considerable reaction to take place before the heat was turned up. Eventually, cylindrical chutes similar to those now in use were installed. Into these chutes the scale is dumped and carried into the empty vessel. Before this convenient means of introducing the scale was adopted, the Ohio Works had satisfactorily demonstrated that roll scale would increase production, by blowing 107 heats in one 12-hr. turn (1,087 tons) with one blowing engine, blowing one heat at a time; whereas, prior to the use of scale, the best practice at these works was about 80 heats under the same conditions.

In using roll scale and other oxides of iron to facilitate and control the refining of pig iron in the converter, the Bessemer plant has borrowed one of the most active agencies used in the open-hearth process with, as would be expected, much the same results. The effect of such additions to the Bessemer charge may be discussed as to the influence of this practice on quality, production and cost.

Experience has shown that the judicious use of scale in the Bessemer operation will not only increase production and reduce cost, but that at the same time it will improve the general quality of the steel. Most of the data on which these conclusions are based were obtained at the Bessemer plant of the National Works, National Tube Company, McKeesport, Pa., with the assistance of George Hitchins, superintendent of steel works, and others of this company who also took an active part.

Taking up these phases of the subject in order of importance and with special reference to the manufacture of soft, weldable steel for pipe, it can be assumed to start with that the most important element in this problem is uniformity of operation. A higher standard of uniformity, especially in those points which affect the welding quality of the steel, is demanded in the manufacture of steel skelp than for other products, and it is probably true that this is generally obtained under modern conditions. Prominent among the factors contributing to this success is the use of roll scale in the converter.

The influence of this practice on quality is primarily due to the wider latitude in silicon which is thereby given to the blast-furnace operations, resulting in higher average silicon and lower sulphur. To obtain uniformly low-sulphur metal from the blast furnace, the Bessemer department must be designed and operated so as to be able to use without complaint iron that will run from 1 to 3 per cent in silicon. This gives the blast-furnace management a larger margin of safety, thus making unnecessary sudden changes to prevent making iron too hot or too cold for the Bessemer plant. At the steel plant of the National Works, the average sulphur in the steel for 1915 was 0.038 per cent with 95 per cent under 0.050 per cent, the blast-furnace iron averaged for that year 1.77 per cent silicon.

The proper use of roll scale, pig and steel scrap enables the blower to turn down his heats nearer to the same point in carbon by giving a sharper contrast on the final changes in the flame. It also enables all heats to be blown more nearly in the same time and to the same temperature, which, of course, is favorable to uniformity in heating and rolling and makes all dependent operations more systematic.

The introduction of roll scale provides oxide of iron which would otherwise have to be formed by burning about 1¼ per cent of the metallic charge. Somewhat higher silicon must therefore be present

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Paper, substantially as presented by authors before American Institute of Mining Engineers.

when roll scale is used to make up the thermal deficiency.

In the design of a Bessemer plant, about all thė engineer can do with regard to production is to make the vessels sufficiently large to blow the size of heat desired, with a bottom having sufficient blast area to blow the heat in a given time. He would probably use in his calculations a pig iron with 1.00 to 1.25 per cent silicon. If the blast area was figured sufficiently large to blow iron containing 2.00 to 2.50 per cent silicon in the same length of time, the operator would be in trouble when required to blow iron carrying in the neighborhood of 1 per cent silicon. The vessels would slop badly, increasing the loss, and the quality of the steel would deteriorate. A vessel properly designed, with a bottom having sufficient blast area, using 20 to 25 lb. per square inch (1.4 to 1.7 atmospheres) blast pressure and designed to blow a heat of 1 per cent silicon iron with pig scrap in 10 min., will blow a heat of 1.25 per cent silicon iron in the same time if steel scrap is used. When the silicon rises above 1.25 per cent, roll scale and pig scrap can be used, increasing the scale as the silicon rises and so continuing to blow heats in approximately 10 min. When the iron runs above 2.00 per cent silicon, it may be advisable to use steel scrap and roll scale, although the proportions required cannot be laid down according to rule, but must be varied by the operator, depending on mill conditions.

By this procedure, heats can be blown in 10 min. which would otherwise require 18 min.; thus the full capacity of the plant can be maintained regardless of variations in the pig iron.

The Bessemer department of the National Works has three vessels 8 ft. (2.4 m.) in diameter of 9 tons capacity; the bottoms have 18 tuyeres, each having seven holes ½ in. (1.3 cm.) in diameter giving a blast area of 24.7 sq. in. (159 sq. cm.). Using 20 to 25 lb. (1.4 to 1.7 atmospheres) blast pressure, heats of metal with silicon in the charge ranging from 1.00 to 2.50 per cent can be blown in 10 to 12 min. As most of these heats carry over 1.40 per cent silicon, roll scale and pig metal are nearly always used for "scrapping," the roll scale occasionally running as high as 6 per cent.

Steel scrap is not used with roll scale as a rule unless it is desirable to blow the heats more quickly, and this usually becomes necessary only when the silicon in iron rises above 2.50 per cent.

The production of this plant has been increased at least 20 per cent by the use of roll scale in this way. For example, the mill records for the month of March, 1916, show in the table in the next column.

The sulphur in the steel for the above month averaged 0.039 per cent with 94 per cent under 0.05 per cent. The time required to charge the heat, pour into ladle, dump slag, fix stopper, etc., is at least 4 min., which would make an average blowing time of less than 11 min. per heat. This month is fairly representative of current practice at this plant, as the average silicon in metal from the blast furnaces for 1915 and for the first 9 months of 1916 was 1.77 per cent for each period. It is doubtful if this plant could make 80 per cent of this amount of steel without the use of roll scale. The practice of using roll scale was started at this plant in December, 1906, prior to which the silicon in blast-furnace metal averaged 1.36 per cent for 1905 and 1.37 per cent for 1906. The period from June 15 to July 15, 1916, shows an average of 1.90 per cent silicon in blast-furnace metal, the lowest cast being 1.03 per cent and the highest, 2.98 per cent. In Table 3 under column heading "Time of blow" will be found some data obtained on heats blown at the same time and under the same conditions that illustrate the influence of roll scale on time of blow.

Ingots produced, 64,055 tons = 7,132 heats

Charge:
78.4 per cent direct metal averaging 1.72 per cent silicon (only one cast was below 1.00 per cent Si this month, the balance between 1.10 and 2.54 per cent).
10.0 per cent cupola metal 1.22 per cent silicon.
11.0 per cent scrap consisting of { Steel 2 per cent; Pig iron 5½ per cent; Roll scale 3½ per cent

Delays:

Hr.	Min.	
50	26	waiting for iron.
6	24	mechanical repairs.
0	8	electrical repairs.
7	50	converting mill delays.
Total 64	48	

Actual operating time = 583 hr. 12 min., or 14¾ min. per heat per vessel is the average time required to charge, blow and pour out each heat.

To analyze the comparative cost of the practice we have been discussing is naturally a very complicated matter. Some Bessemer superintendents claim that it takes 2 tons of roll scale to make a ton of steel This estimate seems to us excessively high, but even if such were the case we have in this practice a direct method of producing steel far below the cost of any known process.

In order to determine the influence of roll scale by itself, we made several experiments in November, 1916, by running five heats with and without scale at the same time in this plant, all other conditions being maintained constant as nearly as possible. The results of these tests are given in Table 3. The difference in time of blow is the most striking feature. This is entirely accounted for in the shortening of the silicon blow. For example, we give the following records from heats which were carefully watched in this respect, from the last series in Table 3.

Without Roll Scale			With Roll Scale		
Heat No.	To first carbon flame, min.	Finish of Blow, min.	Heat No.	To first carbon flame, min.	Finish of Blow, min.
3	7	14¼	3	2½	10
4	7¾	15	4	3¼	11
5	7¾	15	5	3	10½

The quicker removal of silicon is apparently due to the large excess of oxygen supplied by the roll scale, and to the oxide of iron which remains in the bath available for combination with the silica. Silica is thus removed from the bath as fast as it forms and we have a good slag from the time the vessel is turned up. The rapid reduction of the magnetic oxide is clearly indicated by the chilling effect on the heat, which is equal to about one and one-half times that produced by the same weight of pig iron.

To determine whether a larger percentage of iron was carried away in the slags under certain conditions, samples of mixer metal and slag were taken for analysis throughout the month of November, 1916, with results shown in Table 4. This indicates that these slags are fairly uniform. At least, the combined iron in the slags does not vary with the silicon in the charge, as would be expected if the variable amount of roll scale added had any material influence on the slag. As the converter slags were as a rule observed to have the same physical consistency as well as practically the same analyses under this practice, it may be assumed that the free iron or shot carried away in the converter slag is also proportional to the weight of slag produced, which varies with the silicon in the charge.

During the month of November, 1916, when the experiments referred to in Table 3 were made, we weighed all the converter slag that was shipped from the mill, and weighed or estimated the loss in the lining and bottoms of the converters. With these data and the analyses of the slags and the charge throughout the month, we have computed the loss in metal in the slag as follows:

Converter Slags

Weight of slag calculated from silica contents per charge of 22,400 lb.:
100 lb. from bottom × 80 per cent = 80.0
50 lb. from sides* × 97 per cent = 48.5
128.5
1.74 per cent Si in charge = 0.0174 × 22.400 × 60/28 = 835.2
Total SiO_2 in charge = 963.7

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* Estimated by measuring vessel before and after 500 heats.

Slags carry 60 per cent SiO_2 (averaged from analyses of samples after removing shot).

$$\text{Silicates in slag} = \frac{963.7}{0.60} = 1{,}606 \text{ lb.}$$

Slag per heat, as weighed for month = 2,016 lb. (= 9 per cent of charge)
Theoretical weight of slag from SiO_2 in silicates = 1,606 lb.
Shot and scrap = 410 lb. or 20.3 per cent of slag
Combined iron in silicates = 16 per cent × 1,606 = 256 lb. = 12.7 per cent of slag
Total iron in slag = 33.0 per cent

The silicon in the charge for the group of heats included in the test heats referred to in Table 3 was practically the same as the average for the entire month. The actual converter and cupola loss for this month amounts to 9.05 per cent, which is somewhat above the average, due to an unusually high percentage of shot in the slag and to the fact that the average silicon for this month was comparatively high. The converter and cupola losses for this month have been analyzed as shown in Table 1.

TABLE 1.—Converter and Cupola Losses—National Works, Month of November, 1916.

Loss in Direct Iron.	Per Cent	Loss in Cupola Iron.	Per Cent
Carbon	4.11	Carbon	3.90
Silicon	1.89	Silicon	1.66
Manganese	0.70	Manganese	0.60
	6.70	Cupola loss	1.24
			7.40

Known Losses of Other Materials

Steel scrap	0.35
Ferromanganese	30.00
Roll scale	(?)
Per cent, vessel and ladle slag	9.00
Total iron in slag	33.00*

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* This is about 10 per cent higher than the yearly average for 1915 due to stiffer vessel slag and greater amount of shot included.

Material Charged	Per Cent of Charge	Per Cent Loss Chge	Per Cent of Total Loss
Direct metal	76.58	6.70	5.13
Cupola metal	10.76	7.40	0.80
Steel scrap in vessels	4.27	0.35	0.01
Ferromanganese and ferrosilicon	0.57	30.00	0.17
Roll scale	3.93	.....	(?)
Pig iron (for scrapping in vessel)	3.89	6.70	0.26
Iron in slag (9.0 per cent × 33.00)	.....	.....	2.97
			9.34
Less credit received for iron in slag returned to blast furnaces for month			0.15
Theoretical loss			9.19
Actual loss			9.05

For comparison we give, in Table 2, the converter and cupola losses at this plant for 1915, which are more representative of the average practice.

TABLE 2.—Theoretical and Actual Losses for 1915—National Works

Loss in Direct Iron	Per Cent	Loss in Cupola Metal	Per Cent
Carbon	4.25	Carbon	4.00
Silicon	1.76	Silicon	1.56
Manganese	0.70	Manganese	0.60
		Cupola loss	1.26
Total	6.71		
			7.42

Loss of Other Materials Added

	Per Cent		Per Cent
Loss in steel scrap (Mn)	0.35	Per cent vessel and ladle slag	*8.20
Loss in ferromanganese	30.00	Iron in slag	23.40
Loss in roll scale	.....		

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* Estimated.

Material charged.	Per Cent of Charge	Per Cent Loss	Pr Ct of Total Loss
Direct metal	77.15	6.71	5.17
Cupola metal	11.49	7.42	0.85
Steel scrap used in vessels	3.57	0.35	0.01
Ferromanganese and ferrosilicon	0.59	30.00	0.18
Roll scale (metallic)	2.80	.....	(?)
Pig iron used for scrapping vessel	4.40	6.71	0.30
Plus iron in slag (8.2 per cent × 23.40%)			1.92
			8.43
Less credit received for iron in slag			0.09
Theoretical loss			8.34
Actual loss			8.45

The use of roll scale was started at the National Works in December, 1906. For that year the silicon in the charge averaged 1.29 per cent. Assuming all other conditions to be unchanged, the increase in con-

TABLE 3.

Exper. Run No.	Analysis of Mixer Iron			Weight of Charge in Pounds					Pr Ct Si in Charge	Blast Pres. Lbs. per Sq.In.	Time of Blow Min.	Analyses of Slags					
	Total C	Si	Mn	Mixer Iron	Pig Iron	Steel	Roll Scale	Total Wght				Converter Slag SiO_2	Iron	Mn	Ladle Slag SiO_2	Iron	Mn
No. 1.																	
Without scale.	4.34	1.96	0.84	18,640	.....	3,160	.....	21,800	1.80	23	19.0	65.27	15.30	8.11	53.12	15.70	14.00
With scale....	4.21	2.20	0.81	19,180	.....	2,130	1,210	22,520	1.90	23	12.5	61.80	17.50	7.84	50.10	16.20	13.44
No. 2.																	
Without scale.	3.98	1.60	0.76	19,000	3,000	.....	.....	22,000	1.63	25	18.6	63.60	16.20	8.11	48.06	15.60	12.84
With scale....	4.06	1.63	0.77	19,000	2,000	.....	1,000	22,000	1.56	25	10.0	62.26	17.70	8.64	48.64	16.50	12.97
No. 3.																	
Without scale.	3.92	1.62	0.70	19,100	3,500	.....	.....	22,600	1.62	25	18.9	65.34	16.50	8.24	50.48	13.00	11.59
With scale....	4.00	1.96	0.75	19,200	2,500	.....	1,400	23,100	1.87	25	11.3	63.40	16.50	8.15	52.04	15.90	12.94
No. 4.																	
Without scale.	4.24	1.79	0.64	19,020	2,540	.....	.....	21,560	1.80	25	15.0	63.50	14.50	6.82	47.40	18.20	18.21
With scale....	4.00	1.77	0.68	19,080	1,550	.....	1,000	21,630	1.69	25	10.2	60.50	18.70	8.01	47.00	16.10	16.95
Averages ..	4.08	1.82	0.74	......	.....	.....	.....	......	1.73	..	....	.....	.....	....	.....	.....	.....

NOTE.—The average weight of all converter slags produced for this month was 2,010 lb. per heat. The ladle slag averaged 4.17 lb. per heat and was quite constant.

verter loss due to raising the silicon in the charge to 1.61 per cent, as was the case in 1915, would be about 0.3 per cent, based on the slag carrying 24 per cent iron in each case.

There is probably a little more loss due to the greater activity of the reactions in the converter when using dirty or moist roll scale, but this is recovered for the most part and is credited to the steel works. The free iron now lost in the converter slag might also be recovered to advantage so that the necessary excess loss by this practice would consist of only a little more than the combined iron in the larger volume of slag due to a higher content of silicon. As the per cent of combined iron in the slag has been found to be practically constant, this would be lost in any case in proportion as the silicon in the charge is raised, which we maintain is warranted to a certain extent on the basis of better quality alone.

TABLE 4.—Analysis of Converter Slag and Mixer Metal for Same Heat or Group of Heats—National Works, November, 1916.

Date	Analyses of Mixer Iron			Analysis of Vessel Slag*		
	Si	C (Total)	Mn	SiO_2	Fe (Combined)	Mn
Nov. 1-2-3.....	1.90	....	0.75	60.70	16.40	8.21
Nov. 4 6-7.....	2.00	....	0.76	61.50	18.10	8.40
Nov. 8-9.......	1.90	....	0.77	62.70	16.40	7.75
Nov. 10.........	1.60	3.98	0.76	63.60	16.20	8.11
Nov. 11.........	1.74	4.02	0.86	.....	16.70	....
Nov. 13.........	1.78	4.12	0.83	.....	16.70	....
Nov. 14.........	1.80	4.58	0.74	.....	20.20	....
Nov. 15.........	1.93	3.90	0.72	.....	16.50	....
Nov. 16.........	1.68	4.16	0.82	.....	17.10	....
Nov. 17.........	2.40	4.28	0.85	.....	14.80	....
Nov. 18.........	2.00	4.04	0.74	.....	17.30	....
Nov. 20.........	1.96	4.00	0.75	63.40	16.50	8.15
Nov. 20.........	1.62	3.92	0.70	65.34	16.50	8.24
Nov. 21.........	1.46	....	....	.....	16.70	....
Nov. 22.........	1.92	....	....	.....	15.40	....
Nov. 23.........	1.96	....	....	.....	16.30	....
Nov. 24.........	1.42	....	....	.....	18.00	....
Average	1.82	4.10	0.77	62,78	16.85	8.21

* After removing metallic shot. The combined iron in average monthly samples of Bessemer slags for 1916 varies from 13.69 to 17.52 per cent, with an average of 15.92 per cent for the year.

Against this loss, most of which is in consequence of the larger volume of slag produced, we must credit a 20 per cent reduction on steam cost and a similar reduction in most of the other items of cost, together with a 10 per cent increase in scrap-melting capacity due to the use of higher-silicon iron. It is hardly necessary to produce further figures, even if we had them, to indicate that there is a substantial saving in cost of production by this practice. It may be said that it costs a little more to make the higher-silicon iron, but this is obviously more than offset by the advantages obtained, some of which, such as increased yield of finished product, are difficult to compute.

We have attempted to give briefly the results of 10 years' experience in the use of roll scale under the conditions that prevail at this particular plant. However, in summing up the benefits derived, as "better steel," "increased production" and "lower cost," we would not have the reader conclude that this is a "cure-all," as the practical Bessemer operator will readily appreciate that there are many other details such as temperature, ladle reactions, etc., which will require just as much attention as ever. Aside from all other factors, however, the judicious use of roll scale is a study within itself.

Manganese in 1916.

Preliminary estimates by D. F. Hewett, of the United States Geological Survey, Department of the Interior, show that the production of manganese ore in 1916 was about 27,000 tons, the greatest since 1888 and nearly three times that in 1915, which was 9,709 tons. The estimate does not include manganiferous iron ores not include manganiferous iron ores that contain less than 40 per cent of manganese but it is very probable that the production of ores of this class also was much greater than in 1915. This output has come largely from seven states, and the order in production will probably prove to be as follows: California, Arkansas, Arizona, Georgia, Virginia, Utah Colorado. This order is interesting, because this i the first year in which a western state remote fron the steel producing centers has contributed the larges amount of. manganese ore. The activity amon manganese mines in California is due largely to th market for ores provided by the Noble Electric Ste company at Heroult. It is not yet possible to stat the production of high-grade ores adapted for use i dry batteries, but reports indicate that it will exceed 2,500 tons and therefore be five times that in 1915. Ores of this class are now produced in Arizona, California, Utah, Colorado, and Virginia, but the amount produced is still scarcely one-tenth the normal demand.

The prices paid for manganese ore adapted to the manufacture of ferro-manganese rose from a maximum of $22.50 for 50 per cent ore in 1915 to $32.50 in March, 1916. Except for minor fluctuations, which depended on temporary variations in demand, prices were nearly constant until the last month of the year, when sales at prices as high as $39 for 50 per cent Indian ore were reported. There were rumors that a contract for the delivery of 200,000 tons of Brazilian ore during 1917 was placed at $23 per ton f.o.b. Brazilian port, from which the freight rate to Baltimore is $12 a ton. Ore adapted to the manufacture of dry batteries (containing 80 per cent of manganese dioxide and less than 1 per cent of iron) continues to sell for about $85 a ton.

Imports of manganese ore for the first ten months of 1916 amounted to 495,299 tons, of which 401,177 tons came from Brazil. For the same period of 1915 Brazil supplied 181,258 tons out of the total of 192,286 tons. There is a prospect, therefore, that the imports for the entire year will prove to have been almost double those of 1915—320,778 tons. Considering the small part of the demand that was supplied by Brazil during the eight years prior to 1914, it is reassuring to know that the deposits of that country can be made to yield such enormous quantities of ore. Imports from India, Cuba, Panama, and Japan were also greater than in 1915.

Imports of ferromanganese for the first eleven months of 1916 were 73,435 tons, which is nearly 50 per cent more than for the corresponding period in 1915, though bearing a smaller ratio to the domestic production. Prices reached the highest figures ever recorded in the United States in April, 1916, when, it is reported, $400 a ton was paid for a small lot for immediate delivery. For the remainder of the year the price decline steadily to $160 a ton in October, then rose to $175 again in December. The price of spiegeleisen carrying 20 per cent of manganese ranged from a maximum of $52 in July to $40 in December.

An important consequence of the prevailing high prices of manganese alloys is the attempt on the part of steel makers to use substitutes. The extent to which substitutes for manganese in steel may be used has not been determined, but experiments by several steel works show that an alloy of iron, carbon, and titanium may be satisfactorily used to replace a part of the ferromanganese commonly added.

Although a number of mines in Virginia, Georgia, and Arkansas were reopened during 1916, the greatest activity is reported among mines in California, Arizona, Utah, New Mexico, and other western states. This is due in part to the operation of electric reduction plants in California and Washington, but more largely to the low percentage of iron in some of the western ores. Few eastern mines that operate residual deposits can produce at a profit in large quantities ore that contains less than 1 per cent of iron, and therefore most of the eastern mines ship their product to eastern furnaces to be reduced to ferromanganese. The inacessibility of most western deposits makes it unprofitable to ship ore to eastern makers of ferromanganese, even at the high prices they are now offering for manganese ore. On the other hand, many western deposits are known and more have been discovered during recent years, which are capable of producing manganese ore with less than 1 per cent of iron. At prevailing prices for such ores, they may be profitably shipped as far east as New York. There is a prospect at present that several western mines may be able to ship high-grade ores to eastern markets even when prices recede to the level of years prior to 1914.

Experiments on Earth Pressures.

By P. M. Crosthwaite.

The writer presented a paper under the above title before the British Institution of Civil Engineers recently, in which he outlined the following points which are of interest in connection with the storing of ore, coal and other bulk supplies at the blast furnace or steel plant, according to London "Engineering."

The paper commences with a short account of Rankine's theory of earth-pressure, and the principles and assumption on which it is founded. Descriptions of former investigations are given in some detail, namely, those of the late Sir George Darwin, and Messrs. Goodrich, Wilson, Bell and Meem. The author concludes that of the experiments made by these investigators to investigate the lateral pressure of earth, those in which model walls were used are of greatest value, but points out that if models are of any size the experimental difficulties are almost insuperable.

The author's experiments, a number of which are described and illustrated in the paper, were made by loading a plunger with known weights and measuring the penetration when the plunger had come to rest after the application of each weight. The materials were enclosed in an open bucket, and their weight was determined.

With those data the value of Φ, the angle of internal friction, can be obtained from Rankine's well-known formula for the safe depth of foundations—

$$d = \frac{P}{W}\left\{\frac{1-\sin\Phi}{1+\sin\Phi}\right\}^2$$

when d denotes the penetration; P the pressure in pounds per square foot; and W the weight of the material in pounds per cubic foot under standard density conditions.

If the formula is true, and the pressures be plotted against the penetrations, the resulting curve is a straight line, and Φ as calculated from the formula should equal the angle of repose.

With sand, garden earth, and cinders and ashes the resulting curves are straight lines, but it was found that the value of Φ varied with the state of aggregation of the material, i.e., whether it was lightly poured into the bucket, shaken in, or well pounded in. When the material was deposited in the bucket as lightly as possible the angle of internal friction was the same as the angle of repose, but with more consolidation the angle was much greater.

From these materials the author concludes that Rankine's theory holds, provided the proper angle of internal friction is used and not the angle of repose. If, however, this angle is used it would be necessary to introduce a factor of safety into the formula, for a wall designed without one would be theoretically just strong enough and no more. In Rankine's formula there is no factor of safety, and it is concluded that Rankine saw this, and used the angle of repose as covering the worst conditions that need possibly be provided for. The author's experiments show that, for the materials tested, work designed by Rankine's formula, using the angle of repose, would have a factor of safety of 2½ to 4, and he considers that these are not unreasonable figures for such materials.

The experiments on clay give altogether different results, for instead of the penetration varying as the load, it varies as the square of the load, and the penetration curves are parabolas. These results, which were altogether unexpected, are completely confirmed by larger experiments carried out by Messrs. Coode, Matthews, Fitzmaurice and Wilson, and by Mr. McAlpine in New York.

The author is able to give no physical explanation as to why the penetration in clay should vary as the square of the load, but leaves it to the physicists. The law must be capable of some rational explanation, and, if true, it upsets all earth-pressure theories when they are applied to clay; for all accepted theories assume that the angle of internal friction is the same as the angle of repose, and that its value is independent of the pressure.

It is suggested that the subject is worthy of further investigation, but that such could hardly be made by a private individual, for the work is tedious, each experiment taking 24 to 48 hours. Moreover, if the investigation is to be properly carried out, physical and chemical analyses of the clays will be required that could only be made in a well-equipped physical laboratory.

In conection with the earth slides experienced at the Panama Canal, it has been suggested that in clay and shale cuttings there is a critical depth beyond which the sides will not stand, and the author's experiments on clays clearly show that for these this must be the case. Where Φ is independent of the pressure the depth of the cutting cannot affect the stability of the slope, but where the angle decreases with the pressure it is evident that eventually a depth will be reached beyond which its sides will not stand.

This decrease is clearly shown in one experiment on mud, for which the angle for a pressure of 0.25 ton per square foot was 17 deg. 15 min., which decreased to 2 deg. 10 min. at a pressure of 1.25 ton per square foot, when it was little better than a liquid.

Reagent for Etching Mild Steel.

The reagent is composed of ferric chloride, 30 gram.; concentrated hydrochloric acid, 100 c.c.; cupric chloride, 1 gram.; stannic chloride, 0.5 gr.; and water, 1 litre; and it is necessary that the surface of the metal to which it is applied be perfectly clean. The reagent deposits a thin film of metallic copper. On hardened steels, especially of low and moderate carbon contents, the results were similar to those obtained with picric acid, etc., but the outlines of the copper films were very sharp, especially on martensite; troostite and sorbite were darkened. On practically pure carbon steels with the usual pearlite-ferrite structure, the effect was the reverse of that obtained by picric acid, etc., the pearlite being unaffected. The reagent proved specially useful for revealing the distribution of phosphorus in mild steels, giving results which compared favorably with those obtained by Stead's method of heat-tinting. In addition to the typical etching effect, discolored patches surrounding small black pits were frequently observed, usually grouped around a slag-enclosure.

Cementation of Iron by Solid Carbon.

The contradiction in the results given by different experimenters, such as Gullet and Griffith, Weyl and others, on the subject of the cementation of iron by solid carbon, is due to the fact not well defined, either as to composition or as to pressure. New experiments, where minute precautions were taken to avoid these sources of error, have shown that there is absolutely no cementation of iron by solid carbon at about 950 deg. C., when there is no gas present which can react with the carbon or the metal.

The spring meeting of the American Iron and Steel Institute, James T. McCleary, New York City secretary, will be held at the Waldorf-Astoria Hotel New York, on May 25 and 26, with the technical papers presented on the earlier of the two dates.

Potash as One Blast Furnace By--Product

Concluding the Discussion of the Possibilities Involved in the Blast Furnace as a Producer of Potash and Compounds in Commercial Quantities—Results from Furnace Campaign.

By R. J. WYSOR.

All the remaining potash and soda present in the burden, not previously accounted for, is sublimed and passes out in the form of various salts or compounds as a fine fume.

Various investigators have studied blast-furnace flue dust with special reference to its potash content, but almost entirely from a scientific standpoint. It is true that at least one American and one foreign patent have been issued for the recovery of potash in flue dust, but no evidence has been found that any practical application has thus far been made. And, so far as can be ascertained, the first commercial disposition of the flue dust as a fertilizer was made by us at Bethlehem somewhat more than 2 years ago.

The progress of the alkalies in our practice will now be traced from the furnace top, through the gas mains, washers, stoves, boilers and stacks.

Alkalies in Dry Dust Between Furnace and Washer.

Besides the dust carried out by the relatively small amount of gas escaping from the furnace top, and the insignificant quantity permanently deposited along the mains, all the dust under the above heading is removed from the dust catcher. Representative bi-weekly samples of the dust-catcher flue dust were taken over the same period during which the slag samples were secured and analyzed, with the results shown in Table 4.

TABLE III.

Furnace	Period Included, 1916	Fe	Ign. Loss	CN	Total K_2O	Total Na_2O	Water Solble K_2O	Water Solble Na_2O
A	6/25 to 7/8	40.7	17.3	None	0.63	1.45	0.40	0.35
A	7/9 to 7/22	47.2	11.5	None	0.64	1.47	0.27	0.16
C	6/25 to 7/8	59.8	1.7	None	0.50	0.94	0.29	0.30
C	7/9 to 7/22	53.8	8.8	None	0.69	1.07	0.24	0.16
D	6/25 to 7/8	40.5	18.1	None	0.59	1.30	0.40	0.42
D	7/9 to 7/22	43.3	12.9	None	0.88	2.10	0.29	0.22
E	6/25 to 7/8	49.3	9.8	None	0.50	0.90	0.31	0.30
E	7/9 to 7/22	46.3	16.4	None	0.54	1.10	0.17	0.20
F	6/25 to 7/8	46.6	14.6	None	0.42	0.85	0.20	0.22
F	7/9 to 7/22	50.6	8.9	None	0.59	1.20	0.22	0.18
G	6/25 to 7/8	47.4	8.1	None	0.55	1.50	0.25	0.20
G	7/9 to 7/22	43.3	12.2	None	0.87	1.60	0.29	0.24
Average for all furnaces first period........					0.53	1.16	0.31	0.30
Average for all furnaces second period......					0.70	1.42	0.25	0.20
Average for all furnaces both periods........					0.61	1.29	0.28	0.25
Ratio average total potash to average total soda..........								1:2.1
Ratio average water-sol. potash to average water-sol. soda..								1:0.9
Ratio average water-sol. potash to average total potash..								1:2.2
Ratio average water-sol. soda to average total soda........								1:5.2

A much greater percentage of the total potash than of soda is present in a water-soluble condition.

The entire absence of cyanides in this dust, and even in concentrated alkaline samples, presented further corroboration of the fact that in normal operation practically no cyanide is carried in the gas current from the furnace top. That it may be an occasional constituent of flue dust, because of abnormal furnace conditions, is evidenced by several records at hand, notably by the following abstract.

The greater part of the CN compound dissociates higher up in furnace and aids in the ore reduction. A portion passes away unaltered with the gases and is deposited in the flues. CN in small quantities was found in flue dust by Ledebur. It may, however, occur in considerable quantities as the Austrian Alpine Company found to its cost. In the summer of 1901 about 20 tons of flue dust from the Hieflau charcoal blast furnace in Syria was tipped into the river Ems, and an enormous quantity of fish were killed. Cyanogen was found in the dust and 2,800 pounds damages had to be paid.

Also, an instance of a large quantity of cyanides being evolved from the furnace top occurred at the Colebrook Furnaces, Lebanon, Pa., several years ago. I trust that this occurrence will be enlarged upon in the discussion.

It will further be noted that there is a considerable enrichment of this flue dust by the alkali fume. At one furnace where dry gas is used in the stoves, there are two Brassert Witting dry whirlers and a long dry dust main with numerous dust legs between the dust catcher and stoves. This dust is increasingly fine and somewhat lighter in color at each of the points removed. Potash determinations at different times have shown a gradual increase in the successive samples, running as high as 5 per cent at the stove burners.

Tests made at different times show that our dust catchers remove an average of about 100 pounds of dust per ton of pig iron produced. Using the average percentage of alkalies in flue dust for the four weeks' period, we find:

TABLE IV.—Analyses of Dust catcher Flue Dust.

	Pounds	% of Total Charged
Average potash in flue dust from dust catcher per ton of pig	0.6	1.8
Average soda in flue dust from dust catcher per ton of pig	1.3	2.3

The ration of total potash to total soda present is roughly about the same as in the average charge entering the furnaces.

Effect of Primary Washers on Alkalies in Dust.

At Bethlehem we have in service a type of tower spray washer, in common use in this country. All of the gas for stoves and boilers, as well as for gas engines, is washed, except from one furnace. Naturally, it would be thought that practically all of the alkaline material in the dust, most of it readily soluble in water, would be removed in the wet washers. The bulk of it is washed out, but it is a remarkable fact that much of the water-soluble alkalies remains in the gas current after leaving the washers. Calculations based on alkalies charged into the furnaces, lost in the slag, dust catcher, stack gases, etc., and recovered from the stoves and boiler settings, indicate that about 20 per cent of the total potash (apparently only about 5 per cent of the soda) entering the primary washers, passes through them. The explanation for this fact is that the particles of fume are in such an exceedingly fine state of division that they escape contact with the relatively large drops of water. In my opinion, any washer that will successfully clean blast-furnace gas rich in this fume must employ spray nozzles or other devices which will discharge water in a fine mist, thus insuring intimacy of contact between dust and water particles. Our washers at present perform the function of selective precipitation, eliminating the relatively coarse and heavy iron ore and coke particles, while delivering the lighter particles of dust and fume into the primary clean gas main.

Alkalies in Dirt from Primary Clean Gas Mains.

The mains carrying gas from the primary washers to stoves, boilers and secondary gas-cleaning plant accumulate dirt or mud gradually, and are washed out at intervals of every 2 or 3 months. This dirt is black when wet but after being dried is dark gray, and after the fine particles of coke dust are burned out, it is of a light-gray or reddish-white color. Sometimes drippings from a clean-out door along a gas main will form beautiful long stalactites. This material is in general appearance similar to the stalactites mentioned as exuding from the furnace shell. A typical sample was found to have the following proximate composition: SiO_2, 0.28 per cent; $Fe_2O_3 + Al_2O_3$, 0.68; CaO, trace; MgO, 0.25; K_2O, 44.63; Na_2O, 7.13; Cl, 37.22; CO_2, 7.78; CN, trace; NH_4, none. The almost utter absence of cyanide in this concentrated alkaline material is worthy of note.

Alkaline Dust in Stoves and Boiler Settings.

The dark, wet dirt carried into the stoves, which at our plant are of the three-pass type, is dead burned, of course, the combustible or volatile constituents, etc., being expelled. The residue, in the form of an impalpable powder, collects to some extent in the bottom of the combustion chambers, a relatively large amount gathers in the bottoms of the second and third pass checkers while the largest portion is carried out in the stack gases.

In the combustion chambers the dust frits together in friable masses. The accumulation is not great, the wells being cleaned out at intervals of about 2 months. However, the action on the brickwork is serious. All over the inner surface of the combustion-chamber walls, the lower surface of the dome, and the second pass checkers for a depth of several feet, a deep-green glaze is formed, or the brickwork is honeycombed. Along the fire-clay joints between the brick, the action is especially marked. Stove brick of a high silica content invariably glaze or slag, whereas those with a lower percentage of silica are more readily honeycombed or excoriated by the alkaline fume. Analyses of these materials show the following interesting results:

	SiO_2	Fe_2O_3	Al_2O_3	K_2O	Na_2O
Green slag No. 1..........	60.66	2.30	14.55	16.30	6.03
No. 2..........	58.44	2.50	12.60	18.07	8.29
Original brickwork	79.70				
		19.70		0.25	
Excoriated brick	40.17	26.70		20.84	8.04
Original brickwork	52.50	2.00	43.0	1.95	

The thermal efficiency of the stoves is reduced, of course, by this glazing, erosive and honeycombing action, though repairs seldom have to be made during a furnace campaign.

The fine, light-colored dust, which accumulates in the bottom of the second and third passes, is the material of commercial interest to us. It is cleaned out at intervals of 3 or 4 months.

In the boiler houses the dust accumulates and is recovered every few days from the combustion chambers, from the passes and occasionally from the horizontal flues leading to the stacks. It becomes increasingly fine and richer in potash in its progress. The boiler tubes, of course, become coated with the dust and must be blown off with a steam or air lance.

The white fume continuously issuing from the top of the stove and boiler-house stacks is approximately of the same composition as that reclaimed in the last passes.

Properties and Quantity of Alkaline Dust Recovered for Sale.

As previously indicated, the dust recovered from the combustion chambers and boilers is a light, friable sinter, whereas the larger amount reclaimed from the passes and flues is in an exceedingly fine state of division. When drawn out of the stoves or boiler settings hot, it runs almost like quicksilver, but it absorbs a certain amount of water readily, and becomes somewhat clammy and heavy.

An attempt was made to obtain some data on "angle of repose" of the fine dust. However, the cold, freshly dried dust behaves very differently from the hot material. A large, glass funnel at a fixed height over a plane surface was employed in the experiment. Comparative tests with white sand and two kinds of ore, prepared to various degrees of fineness, down to ultra 100-mesh, all yielded heaps with angles of repose of about 40 deg., whereas the stove-dust samples varied from 43 deg. to 50 deg.

Sieve tests were also attempted. By careful sifting, it was found that all of the alkaline dust would pass a

300-mesh sieve. It is a true fume. The small residues remaining on the various sieves, when examined under a magnifying glass, were found to be chiefly eroded brickwork.

Specific-gravity tests, also, cannot be made with accuracy. The lightest dust, without compression, will run well below 0.50 apparent specific gravity. Samples taken from the checkerwork of five different stoves, and showing potash contents of 10 to 14 per cent, when tamped down gently in large glass measuring cylinders, showed the following varying densities: 0.68, 0.69, 0.73, 0.89, 0.96.

Three typical samples of fine stove dust were taken from different furnaces, and after being screened through a 300-mesh sieve and dried, were sent to an expert microscopist, skilled in examining such material. All of the samples showed the same characteristics as shown by the following quotations direct from the microscopist's report.

"The general characteristics in this dust are: Very fine, spherical particles; the large proportion of them as single particles, but many united into groups and held together as by a gelatinous mass; the large majority of the particles are nucleated, the nuclei, however, varying greatly in size, as do the particles themselves; the nuclei may be several or but one in a particle, and are of a dark orange or brown color; the form of the particles is spherical to pear-shaped, while the form of the nuclei is practically spherical. The nuclei are not always confined to the inner or central part of the particles, but may be on its surface.

"One photograph of each of the samples A, B and C was taken by means of a paraboloid dark ground illuminator, of approximately 500 diameters. They tell nothing of the detail of the individual particles, but they do show clearly the grouping of the particles into aggregates of greatly varying sizes and forms. These aggregations are merely formed by the mutual attractions; that is, each particle is within the radius of attraction of the other. Photograph A shows particularly many single and individual particles, and represents a characteristic field of the samples. Photograph B shows a larger group, or one of the largest groups, while photograph C represents smaller groups. It should be said that a larger group is reduced easily to smaller ones by agitation or stirring or crushing. No detail can be possible at this magnification.

"For detail, higher magnifications, with proper color screens and apochromatic lenses are essential."

Difficulty was experienced with these lenses in getting all the particles in a group into focus. The greatest trouble, however, was in getting both the vitreous groundmass and the orange-brown nuclei to show up together. Under the circumstances the photographs are creditable and interesting.

Knowing the exceedingly fine state of division and smooth, spherical nature of the ultimate particles in this fine fume, there is little cause for wonder that so much of it passes through a creditable wet washer untouched.

The water-soluble potash content of the dry, ignited dust, recovered from the stoves and boilers, having previously passed through the wet washers, will vary from about 5 to 20 per cent. Our practice has been to store the material in a large bin, capable of holding two or three carloads. The commercial recovery, begun in 1914, was not thoroughly systematized until the ensuing spring. Table 5 shows the weights and water-soluble potash contents, calculated on the dry basis, of 36 carloads of alkaline dust shipped in the period of 15 months, April 1, 1915, to July 1, 1916. This represents all the dust removed from stoves and boilers serving four 500-ton furnaces, which could be recovered in normal operation, without special effort. Instead of being dumped into a dirt car, the dust was simply emptied into a central bin. A number of other carloads of lower-grade material, contaminated by flue dust from unwashed gas, were also shipped from the other furnaces, but are not included in this tabulation.

TABLE V.

Weight of Carloads in Net Tons	Percentage Water-soluble Potash (K_2O)	Weight of Carloads in Net Tons	Percentage Water-soluble Potash (K_2O)
33.0	10.05	34.7	7.04
31.3	11.20	32.8	6.22
26.1	9.95	36.4	10.24
24.9	10.65	33.7	7.15
25.4	10.10	32.5	12.00
24.0	11.31	27.3	7.27
25.7	13.96	29.9	11.38
21.1	8.32	31.3	14.22
27.4	9.32	35.0	7.69
27.7	12.17	34.1	9.01
27.9	9.62	26.3	7.55
24.2	11.91	35.1	7.82
26.1	15.92	39.4	6.05
24.0	15.07	27.8	7.84
34.5	11.00	26.4	8.76
28.2	10.27	32.1	8.60
30.6	10.37	32.5	8.58
33.9	8.73	——	——
30.2	14.35	Total 1,073.5	Average 9.90

Total weight of water-soluble potash 106.3 net tons.

TABLE VI—Analyses of Typical Carload Samples and a Rich Stove-dust Sample.

Sample No.	1 Pr ct	2 Pr ct	3 Pr ct	4 Pr ct
SiO_2	22.22	18.07	18.50	22.66
Fe_3O_4	15.24	11.25	2.31	2.30
MnO	0.67	0.67	0.75	0.79
Al_2O_3	11.58	11.04	11.22	11.60
TiO_2	0.66	0.05	trace	trace
CaO	11.69	12.22	13.14	12.49
MgO	7.35	8.49	12.35	6.76
ZnO	2.57	0.82	4.29	2.04
C	5.04	5.43	0.50	0.40
SO_3	6.35	6.13	7.60	10.80
CO_2	1.61	1.94	2.40	0.58
Cl	3.34	5.29	5.40	4.86
CN	None	None	None	None
CNO	None	None	None	None
CNS	None	None	None	None
NH_4	None	None	None	None
Total K_2O	10.87	14.40	16.94	19.71
Total Na_2O	3.74	7.30	7.06	7.34
Water-soluble K_2O	7.55	12.00	15.92	17.04
Water-soluble Na_2O	3.28	3.94	4.44	3.98
Ratio water-soluble to total K_2O	0.69	0.83	0.74	0.86
Ratio water-soluble to total Na_2O	0.88	0.54	0.63	0.54
Ratio total K_2O to total Na_2O	1:0.35	1:0.51	1:0.42	1:0.37

Complete analyses of three typical carload samples and one especially rich stove-dust sample, containing approximately 20 per cent water-soluable potash, are given in Table 6.

No readily volatile constituents, such as many occur in the unignited dust, of course, are to be found after roasting.

In general, the ratio of water-soluble to total potash is higher than in the case of soda.

The preponderance of both total and water-soluble potash over the corresponding soda determinations is impressive, which seems to show the much greater removal of the latter in the wet washers.

If we assume that the total soda content in the stove and boiler dust averages 40 per cent of the total potash content, and the water-soluble potash 80 per cent of the total potash, as appears reasonable from the foregoing analyses, then the total alkalies recovered in the fertilizer material in the above period is found to be:

Total potash	118 gross tons
Total soda	47 gross tons

Calculating on the basis of pig produced in the above 15-month period, the alkalies recovered in terms of total charged are as follows:

	Pr Ton Pig, Pounds	% of Total Charged
Total potash recovered in fertilizer material	0.3	1.3
Total soda recovered in fertilizer material	0.1	0.3

The amount of potash recovered, though of considerable tonnage and value, is an insignificant percentage of the total charged.

At furnace plants using burdens rich in potash where the gas is unwashed, a considerable recovery still can be effected, though some precautions must be taken to avoid the coarser, raw flue dust. Several other furnace plants in the East, acting upon our suggestion, made directly or indirectly, have been recovering potash-bearing flue dust during the last year and a half.

Alkaline Dust Escaping from Stove and Boiler-house Stacks.

Some idea of the relative amount of alkalies discharged per unit value of gas from blast-furnace stove and boiler stacks may be gained by observing the color and depth of the fume. Dirty gas, of course, will obscure greatly the fine, white, alkaline fume. In Western practice, with washed gas, the escaping stack gases show a thin, white color. In our practice the stack fume is much heavier.

About 2 years ago we made a series of tests, extending over a period of about a week, to determine the approximate amount of potash lost through our boiler-house stacks. The average results on the two largest stacks were as follows:

Average amount of dust per cubic foot flue gas (62° and 30"), grains	0.12
Average percentage water-soluble K_2O in dust	14.70
Average percentage total	18.60

Knowing the average volume of flue gas discharged and the average volume of fuel gas consumed by the boiler houses, and produced by the furnaces, we can calculate roughly the weight of potash lost through the boiler-house stacks per ton of pig iron.

No actual tests have been made on potash losses from the stove stacks, but they should be slightly less per unit volume of fuel gas burned on account of the greater baffling action of the stove brickwork. We will assume these losses per unit volume of fuel gas to be 90 per cent as great as from the boiler-house stacks. The soda-potash ratios will be assumed to be the same as in the average stove dust.

	Per ton Pig, Pounds	% of Tot. Charged
Total potash lost in boiler-house and stove-stack gases	2.6	11.2
Water-sol. potash lost in boiler-house and stove-stack gases	2.2	
Total soda lost in boiler-house and stove-stack gases	1.1	2.8

Alkalies Lost in Secondary Wet Washers.

A considerable percentage of the primary cleaned gas at Bethlehem is further cleaned in Theisen scrubbers for gas-engine use. Practically all of the dirt is thus removed, the small amount passing through the fine gas main and into the combustion chambers of the engines having practically no cutting or scouring action, even when as much as 0.03 grain per cubic foot of gas is present. Samples of this dust, recovered near the engines, were of a smooth talcy consistency. The composition is similar to the finest stove dust.

The amount of alkalies removed in the secondary scrubbers, per unit volume of gas, is practically the same as the sum of the alkalies precipitated in the stoves (or boiler passes) and escaping through the stacks. Knowing the gas-engine consumption of fuel gas, the alkalies removed in the wash water, calculated on the same basis as for the stoves and boilers, is readily found to be as follows:

	Per ton Pig, Pounds	% of Tot. Charged
Total potash lost in secondary scrubbers	0.5	2.2
Total soda lost in secondary scrubbers	0.2	0.6

Balance Sheet for Alkalies Charged, Removed and Lost.

Bearing in mind the extremely difficult nature of the problem, and the necessity for including a number of estimates, I will endeavor to summarize a rough balance sheet for alkalies, charged and produced in our average blast-furnace practice. Further, it will be remembered that this balance sheet is approximately representative of our conditions only.

Apparently there is a greater loss of soda than of potash in the primary washer. This may be due to the greater solubility of the sodium salts, or to the larger size or possibly to the difference in contour of the fume particles of sodium compounds.

Cause of "Smoky" Gas.

Every blast-furnace man is familiar with the phenomenon of "smoky" or "calico" gas. This title refers to a peculiar flecked, mottled or streaked appearance of the gas flame and is concomitant with more or less imperfect combustion. In the worst cases the gas will not burn at all in the boiler combustion chambers, even in the presence of good wood fire. It is more frequently noticed in boiler than in stove practice; on account of the greater surface of hot brickwork, which promotes combustion, in the latter. To my knowledge, no trouble in gas engines has been attributed to smoky gas. The more or less imperfect combustion of the gas is accompanied by corresponding amounts of carbon monoxide in the flue gases. The phenomenon occurs in both dirty and primary washed gas, in some plants much more frequently than in others, but at no regular intervals. This is not only a curiosity, but, in plants where blast-furnace gas is at a premium for steam development, its appearance is the cause of concern to the steam engineering and blast-furnace departments. The condition of smoky gas may continue for only a few minutes, or it may last for several hours. In a large plant, it can usually be traced to one, two or three furnaces, seldon being manifest in all the boiler houses, unless they are closely segregated and fed from a common gas main.

TABLE VII.—Balance Sheet for Alkalies Charged, Removed and Lost.

	Potash (K_2O)		Soda (Na_2O)	
	Lbs. per Tn Pig Iron Produced	Per Cent Total Charged	Lbs. per Tn Pig Iron Produced	Per Cent Total Charged
Total charged	22.4	.....	35.6	
Lost in slag	4.5	20.0	6.3	17.0
Lost in fume, etc, from iron and cinder notches, and shell (est. 10 per cent of slag loss)	0.4	2.0	0.6	1.7
Lost in gases from top of furnace (est. 5 per cent total gas losses)	0.9	3.9	1.4	4.1
Lost by combination with brickwork of furnaces, stoves, etc.	negligible		negligible	
Recovered in dust-catcher dust	0.6	2.7	1.3	3.6
Lost in primary washers (est. by difference)	12.5	55.9	24.6	69.5
Lost in secondary washers	0.5	2.2	0.2	0.6
Recovered in stove and boiler passes	0.3	1.3	0.1	0.3
Wastage from mains, stoves and boilers (est. 30 per cent of quantity recovered)	0.1	0.4		0.1
Lost in stack gases	2.6	11.2	1.1	3.1
Total	22.4	100.0	35.6	100.0

So far as I am aware, the cause of smoky gas has not been determined definitely and proved. We have taken numerous samples of gas when it was burning badly under the boilers, but the composition was always found to be normal. The temperature of the washed gas was not found to be above normal, indicating high moisture content, nor was there an abnormal amount of entrained water present.

I am indebted to C. H. Rich, Metallurgist, Alan Wood Iron & Steel Company, for the suggestion that smoky gas is concomitant with increased amounts of fume, in the gas, including cyanide or chloride. Determinations, made under this supervision, showed an enrichment of the fuel gas with one or both of these constituents when the gas was burning badly; elimination of the fume automatically restored a free-burning gas.

To test this idea further, I had several large samples of potassium chloride, sodium chloride and potassium cyanide prepared, in part by grinding to about 40-mesh size, and in part to ultra 100-mesh size. A suitable aspirating spray nozzle, operated by compressed air, was inserted through the breech of a boiler gas burner. The salts were introduced easily in a thin stream through this device. In the coarser condition, none of the salts had any appreciable effect on the caracter of the flame. However, the ultra 100-mesh product of all three produced in a clear flame exactly the same phenomenon as observed in smoky gas. In the case of sodium chloride, which was dry and easily pulverized, the flame could almost be extinguished.

The logical reasoning from these tests is that the cause of smoky gas is a purely physical one, due to the presence of an unusual amount of exceedingly fine fume in the gas, preventing proper contact for combustion between the particles or molecules of fuel gas and oxygen.

It has been our observation that smoky gas is simultaneous with high top temperatures in the furnace, but at irregular intervals. As earlier investigators have suggested, part of the alkali salts probably circulate in the furnace many times, on account of condensation in the upper zone. But the excess accumulation must be expelled at intervals, which naturally correspond to high top temperatures, low stock lines or high hearth temperatures. The fact that cold air admixture in the hot blast, when a furnace is producing smoky gas, will alleviate the condition temporarily, constitutes additional evidence that alkali fume, in considerable quantity, is being evolved during such periods.

A considerable amount of fume also will be noticed when smoky gas is burning, it is difficult or impossible to determine the approximate average size of the ultimate fume particles in blast-furnace gas. The clammy, hygroscopic nature of the material makes microscopic work laborious. Judging from the photomicrographs made at 3,000 diameters, accompanying this paper, there are many minute particles which appear to have a diameter of about 0.01 in. in the photograph, and many others which do not exceed, say 0.04 in. The actual diameter of such particles would therefore be 0.0000033 in., and 0.0000133 in. diameter respectively. Assuming 0.3 grain of fume per cubic foot of fuel gas, and an intrinsic density of 2.0, the number of particles of fume per cubic foot of gas is found to reach the enormous total of over 30,000,000,000,000 and about 500,000,000,000 for the two sizes above mentioned. There would be about 32,000 and 8,000 particles per linear foot respectively, and the distance between centers of the particles would be only 0.000385 in. and

0.00124 in. respectively. These calculations are purely speculative, but they indicate the physical interference possible in the proper combustion of gas by the introduction of a quantity of fine fume particles. It will be readily understood that coarse, heavy particles of dust, such as exist in ordinary unwashed gas, per unit weight, will have much less effect in breaking up the continuity of the gas stream than fine fume.

In connection with Mr. Rich's original suggestion, I offer the above theory in explanation of the phenomenon of smoky gas. If there are other theories, or objections to this one, I trust that proper publicity will be made.

The obvious method of preventing smoky gas is simply to clean the gas more thoroughly, though this is more easily said than done.

Methods for Further Recovery of Potash.

In our present gas-cleaning practice, it appears that there is a loss in the primary washers alone of over half of the total potash charged, or about 12 lb. per ton of pig iron produced, though, as mentioned later, this amount is probably a little high. The amount recovered, while appreciable, and representing almost clear profit, is sen to be an insignificant part of the total, less than 2 per cent. Potash lost in the slag, around the shell and from the top of the furnace, for all practical purposes, is lost beyond recovery. The greater part of the alkali content of the flue dust removed from the dust removed from the dust catchers could be recovered by leaching in water, but the percentage is too low to justify reclamation in this way. However, the potash now lost in wet washers and from stove and boiler-house stacks offers a legitimate and inviting field for its recovery. According to our balance sheet, it appears that about two-thirds of the total potash charged is now lost in the wash water and stack gases, or about 15 lb. per ton of pig iron produced.

About 2 years ago we obtained estimates for cost of recovery of the flue dust from several of our large boiler-house stocks, both by filtering and electrical precipitation methods; but the relatively high cost and the uncertainty in the potash market, deterred an actual installation. Later it was realized that the principal loss of potash was not from the stacks.

At intervals during the course of the last year or more, we have had in operation an experimental Cottrell electric dust precipitator, connected to the raw gas main leaving one of the dust catchers. It is not my purpose in this paper to discuss the operation of the unit, except to state that practically all the dust and fume entering the treater could be precipitated successfully. The color of the dust recovered varied from a light to a dark gray. Several samples were analyzed and showed a potash content of about 10 per cent. The total dust leaving the dust catcher is evidently very much richer in potash than the relatively heavy particles constituting the dust in the dust catchers. However, with the above knowledge at hand, and judging from check calculations on total dust leaving the dust catchers and its theoretical potash content (by difference), it is my opinion that the estimated weight (by difference) of potash lost in the primary washers is somewhat, though not greatly, too high. For our average practice, there should be not less than 12 lb. of total, and probably about 9 lb. of water-soluble potash, now lost in washers and stacks, per ton of pig iron produced.

It may be mentioned that by weak acid treatment part of the insoluble potash content in flue dust may be rendered water-soluble, though this is not likely to be of practical application. Also, the soluble alkali salts can be recovered in tolerably pure form by leaching and evaporation.

It is not my purpose to develop at length the commercial phase of the subject. With the foregoing figures and present potash-fertilizer value as a basis, anyone can readily determine what a very attractive proposition is the recovery of potash from blast-furnace gas at the present time. A word of caution may be appropriate. As previously indicated, the weight of potash charged per unit of iron produced is above the average at Bethlehem. There are only two or three apparently practical methods for recovery on a large scale of potash from blast-furnace gas, and they are expensive and as yet untried for blast-furnace conditions. The price of potash is certain to fall after the war.

On the other hand, the recovery of potash in connection with the thorough dry cleaning of blast-furnace gas, with certain obvious advantages as against wet cleaning, is an attractive proposition to plants now suffering from burdens rich in alkalies. I venture to predict that in the future dry cleaning will be adopted in many blast furnace plants, and that many thousands of tons of potash, hitherto washed, will be reclaimed. Thus will our national resources be strengthened in this important raw material, and the blast furnace will have added another material to its increasing list of by-products.

The subject of alkalies in blast-furnace practice is of a difficult and complicated nature. It will afford much food for thought, both for the philosopher and the practical furnace operator.

In conclusion, I wish to acknowledge especially the coöperation of F. O. Kichline, Chief Chemist, who supervised the difficult analytical work presented in this paper.

Discussion of the above paper by Mr. Wysor, as well as covering some of the other American Institute of Mining Engineers' papers presented in these columns will be reprinted next month. Mr. Wysor's paper is complete with the exception of photographs of samples, which, when once reproduced lost most of their pertinent detail.—Ed.

EDITORIAL

Note of the recent installation of a small gas engine to start the gas engine used to start some blast furnace gas engines rather reminds one of the old saying about great fleas and smaller ones, etc.

Statisticians figure that, if each railway car could be loaded to its capacity—both as to bulk and to weight—the present railroad congested condition would be practically normal within a month.

When wire rods sell for ten dollars a ton more than wire, drawn from the same material, the question is: How much profit does the wire manufacturer obtain from running his mill, and how?

A railroad traffic expert promises us carrier congestion until 1928. Does he have inside information to the effect that railroads are going to cease enlarging their equipment until about that date?

With the Milton dam completed and filled to the brim, it will be interesting to see how much summer production in the Youngstown district increases with adequate supply of water for power and cooling purposes.

Failing to secure enough males to put the "men" in seamen, the Navy plans to recruit women. Why—Teutonic "kultur" recognizes neither person nor sex in its proselyte-by-force plan.

Rumor has it that all the sharks that found Chesapeake Bay such thrilling hunting grounds last summer have withdrawn to other climes, doing obeisance to their more destructive man-controlled prototype from across the seas as they fled.

Since Schwab, as an errand boy, secured his first steel-making promotion largely on account of his vocal and instrumental abilities, why wouldn't it be a good plan for the steel plant errand boys to organize and install an evening course in music—for the eventual betterment of the industry?

Granulated slag is porous, but not enough so when used for fill, as certain steel companies discovered when their entire plant was water-cooled by spring floods, aided and abetted by fills and embankments allowed to encroach on the river channel by the very companies which were thus flooded.

Prominent among the proffers of equipment, output and facilities to the Government in case of war are those from the steel companies—firms which have been singled out by the "trust-busting" element in the various legislative bodies as victims. How many of the pettifogging legislators will now make political capital out of the statement that they have cowed the steel companies—"have them eating out of their hands!"

It is suggested that the carpenters of the country be mobilized and put to work building wooden ships to increase the supply of available submarine targets in the trans-Atlantic course. Why not let them expend their energies and use the lumber in constructing a tall wooden fence along the Atlantic coast—the latter would be about as practical and last about as long under fire; without serving to take valuable supplies to sea there to be lost to us as well as the Allies.

Loyalty and a firm belief in the principles of preparedness have led several steel producers to the authorization of the forming of companies and to the fostering of military drill among their employes. If this keeps on, and an active army unit is required, the drafting of these trained men would defeat the very end of preparedness which they are being equipped to serve—by disorganizing the personnel of the potential munitions plants to give first line troops; when the country can better afford to take additional precautions to hold the trained millmen in their places and put men of less strategic value in the field.

There is an old fable concerning an Arab and his camel. In a howling sand-storm the camel approached his master's tent and begged to be allowed to shelter his head within the tent flap. The permission was granted. As the storm grew in fury the camel pointed out that his neck through the flap allowed the sand to enter in clouds, and suggested that he be allowed to place his fore feet within the tent, whereby his body would block the gap and shut out the wind. The suggestion was followed, though it meant the crowding of the Arab against the farther wall of his tent. Then, without further ado, the camel brought his body entirely within the tent, crowding the defenceless Arab out into the storm beyond. To modernize this fable change Arab to read "railroad," and camel to mean the railroad brotherhoods, with national railroad regulation and rate fixing to replace the sand-storm, and we have the cast complete. Since the last surrender under pressure to the demands of the trainmen, the camel has the whole tent.

PRODUCTION TOPICS

Electric Furnace Hoists.

As a part of a discussion on electric skip and bell hoists before a recent meeting of the Pittsburgh section of the Association of Iron and Steel Electrical Engineers, Frank Smith contributes the following on the subject:

I would like to remind you that the furnace hoist is about the only part of the equipment that does not have a spare to take its place in case of a breakdown or while repairs can be made, and since it is in use almost continually it is very seldom that an opportunity for making repairs other than changing contacts is had. Therefore, it becomes necessary when designing a hoist of this kind to take this into consideration and make as few parts as possible, but with assured reliability. All wearing parts such as gears and bearings should be so arranged that replacements can be made in the least possible time and in such a manner that the new parts will always be in line with the other parts so that no time will have to be wasted in this way.

Spur gearing has recently been replaced with herringbone gears, which are enclosed in suitable gear cases to prevent an accumulation of grit getting into the lubricant and wearing the gears unnecessarily. The herringbone gears, together with the flexible coupling with laminated pins also reduce the gear vibration to such an extent that the life of the armature is very much increased due to better commutation and less wear on the coil insulation.

The controlling device consisting of master switch, stop motion switch and controller, should be of very simple construction, all parts accessible and well protected against ore, coke and other current carrying dusts. It has also been found convenient to have the controller so arranged that the master or operator switch can be located at any point best suited for the operator, so he can take care of other duties which may require his attention. In some cases where electric bell hoists are used for operating the large and small bells automatically, the master switch is located close to the larry car so that the larry operator can start the hoist and in this way do with one man less each shift. The electric bell hoists which can be set for any desired sequence, that is the small bell which opens and closes for each skip load of stock can be set to operate any number of times to one operation of the large bell by simply changing the sequence switch, removes the possibility of the distribution being disarranged by the neglect of the operator in not operating the bells at the proper time or by opening the bells at different speeds which allows the stock to fall to a different location each time, causing very irregular distribution.

The electrically operated bells always move at the same speed and travel the full length of the stroke, therefore insuring the stock will leave the bell at the same angle and result in maintaining a uniform distribution.

Both the furnace and bell hoists are being operated on alternating current, full automatic control, in Europe, and I understand several such units are now under construction for this country, and no doubt will be a subject for a very interesting paper when completed.

Heat Measuring Limits.

In discussing a general paper on the theory of heat and radiation, Prof. W. Trinks, of the Carnegie Institute of Technology stated that many mistakes now made by engineers and would-be engineers could be avoided if the laws of heat transmission were better known. Mistakes are made in obtaining the temperature of gases flowing through a duct of a temperature differing greatly from that of the gases themselves. From personal observation, Professor Trinks says, I know that, in all seriousness, reports have been submitted to chief engineers of large steel plants giving the temperature of gases in regenerators or stoves to four significant figures, whereas, in all probability, the first figure may have been right, but all others were certainly wrong.

The influence of radiation on heat transmission in boilers, heating furnaces, etc., might have been brought out still more strongly. Boilers are usually rated by heating surface; yet heating surface which is not part of the boiler proper may become useful by radiation. If, for instance, a flue carrying hot gases through a boiler is provided with a central core of refractory material, the latter becomes hot and radiates all the heat which it receives from the gases directly to the walls of the flue. The surface of the core has become additional heating surface. In billet heating furnaces, and in many other furnaces of steel works, indirect heating by convection of heat to surrounding refractories and consequent radiation to the piece plays an important part.

Electric Smelting in New Zealand.

The possibility of producing pig iron in New Zealand on a large scale is being thoroughly studied by the authorities as well as by private interests there, says Consul General Alfred A. Winslow, Auckland. It is proposed to use electricity for this purpose instead of coal. There is an ample supply of iron ore in various forms, and plenty of water power that may be developed easily to supply electricity at an exceedingly low figure. The report mentioned states that matters are being well organized with the idea of entering upon this industry on short notice as soon as plans are completed. The report by the chief electrical engineer of the New Zealand government was in part as follows:

The cost of electric smelting of iron from ores in Sweden is less than the cost of the blast furnace process, but the Swedes have a particularly pure ore to deal with, and moreover charcoal is used instead of coke for reducing purposes, while the furnaces are much smaller in size than the blast furnaces in England and America. The consequence, therefore, is that where water power is cheap, and where a special grade of iron is produced from pure ores with the use of charcoal, electric smelting is cheaper than the blast furnace smelting. This is particularly the case if steel making and refining of the iron are carried on simultaneously with the smelting operations, so that the waste gases resulting from the smelting of the ore can be utilized for converting into steel and for refining. On the contrary, where lower grades of ore only are obtainable (and this applies to the vast bulk of ore in the world), and where coal is cheap, and where the demand is such that pig iron can be produced on a large scale at the rate of 700 to 2,000 tons per week per furnace, electricity has not a hope of competing with the blast furnace under these conditions—that is to say, where pig iron has to be produced of ordinary everyday quality from average quality of ore, a blast furnace is unrivalled.

Next, as regards the use of electricity for remelting and refining of iron, electricity is coming into general use at a very rapid rate for this purpose. It will not, however, supersede the Bessemer process or the open hearth process higher quality of steel. It is also being used at a rapidly-increasing rate for foundry purposes, and is specially adapted for this class of work, as it will deal with a greater variety of material than the ordinary converter in use in foundries and engineering works is capable of doing. Another use to which electric furnaces are being put very largely is for reheating and annealing purposes, and it has a special field all its own in the production of special alloys of iron which can not be produced in any other way, or if produced can not be done so economically.

As regards New Zealand, the two principal sources of iron are the Parapara ore and the Taranaki iron sands. The Parapara ore is of medium quality as regards the iron contents, and can probably be more economically produced and smelted by the blast furnace process as long as coke is available in New Zealand. As regards the Taranaki iron sands, I believe that there exists here a source of considerable industry which will be developed in course of time for making a special quality of pig iron in which titanium will play an important part, and also for the purpose of making alloys of iron and titanium for special purposes, and, given a demand for special quality pig iron and ferrotitanium alloys, these could be more economically produced from the iron sands by means of an electric furnace than by the blast furnace process. The reason of this is that the fine grains are not suitable for use in a blast furnace, because they tend to choke the furnace, and also are liable to be carried away by the blast. Consequently some form of briquetting has to be adopted, which adds to the expense, and moreover does not enable the blast furnace to work at its best advantage.

Electric Furnace Operation.

In a series on hydroelectric power and electrochemistry and electrometallurgy in France, C. O. Mailloux, writing in "Metallurgical and Chemical Engineering," under date of March 15, has the following to say regarding the function of the electric furnace in refining steel:

As with the open hearth furnace, the charge may be melted down in the furnace itself, or it may be delivered into the furnace in the molten state. The latter is the preferable way, because the heat required for melting purposes can be obtained more cheaply in an open hearth or a cupola furnace than by electrical means. The most practical way to use the electric furnace, in fact, is to restrict its use to processes and operations which cannot be done so well, if at all, or so cheaply, by any other means.

The process of making steel by the electric furnace comprises two phases or stages, the "oxidation" or "dephosphorization" stage and the "deoxidation-and-desulphurization" stage. In the oxidation stage the metallurgical reactions are substantially the same as in the open hearth furnace; in the second or "deoxidation" stage they are somewhat different, owing, in a great measure, to the fact that the atmosphere in the electric furnace is entirely free from sulphur and almost entirely free from oxygen, whereas both of these reagents always exist in the open hearth furnace, the former being due to the fuel and the latter to the air passing through the furnace. The absence of sulphur and oxygen in the atmosphere of the electric furnace is of no special advantage in the oxidation stage of steel making; it may perhaps be regarded as a disadvantage; but it is of the greatest advantage in the deoxidation stage of the process. The superior quality of the steel obtained by the electric furnace is, indeed, believed to be due in considerable measure to the neutral, non-oxidizing condition of the atmosphere of the electric furnace.

In the first or oxidation stage the presence of oxygen in the furnace atmosphere may be helpful, because the object sought is to oxidize the impurities, carbon, manganese, sulphur and especially phosphorus, as the first chemical step in their removal from the metal. In this stage an oxidizing slag which is highly basic is formed by the melting of iron oxide ore and lime, which are added to the charge from time to time, with, perhaps, a small quantity of silica. This slag, which floats above the molten metal, furnishes, from the iron oxide, the oxygen necessary for oxidizing the phosphorus to phosphoric acid, and it also furnishes, from the lime, the "base" necessary for combination with the phosphoric acid to form phosphate of lime, which remains in solution in the slag. The iron oxide also furnishes oxygen for oxidizing the carbon to carbonic oxide (which burns, producing carbon dioxide, if there is oxygen in the furnace atmosphere), and also for oxidizing a part of the sulphur-dioxide, which escapes. Phosphorus, which is the most objectionable impurity, is the easiest to remove completely. The oxidation of the carbon and manganese proceeds more slowly, in spite of the high temperature in the furnace. Practically all the phosphorus is removed during this stage of the refining process. The sulphur is only decreased by from 25 to 33 per cent.

At the end of the first stage the slag is removed and fresh lime is added to remove the last traces of phosphoric acid and prevent rephosphorization of the bath, by the additions of deoxidizing reagents (containing carbon, silicon, etc.), made to it in the second stage.

In the second stage the presence of oxygen in the furnace atmosphere is actually harmful, the object now being to remove, as completely as possible, the oxygen absorbed by the metal during the dephosphorization stage. The first step is to introduce a small quantity of deoxidizing reagents like carbon, ferro-silicon, etc. The molten metal is then covered with a very basic slag produced by the melting of lime, to which is added a small quantity of sand and fluorspar. The proportions used per ton of steel are the following: About 1 kilo (2.2 lb.) of ferrosilicon (containing 50 per cent of silicon), about 20 kilos (44 lb.) of lime, and 3 kilos each (6.6 lb.) of sand fluorspar. The ferrous oxide formed on the unprotected surface of the metal at the end of the first stage, after the removal of the oxidizing slag, is dissolved by the deoxidizing slag, which turns black. It is necessary to secure the complete deoxidation not only of any iron oxide contained either in the metal or in the slag, but also of the lime in the slag. A certain excess of deoxidizing reagent is therefore desirable. This is provided by the addition of a small quantity of powdered petroleum coke (1 to 2 kilos., or 2 to 4 lb.) per ton of steel. The complete removal of the sulphur, which is so desirable in steel making, depends at this juncture upon the complete deoxidation of the lime in the slag, as this furnishes the reagent (calcium) necessary for the elimination of the sulphur present in the molten metal. We now see the great advantage of the electric furnace. The presence of oxygen in the furnace atmosphere would interfere with the reaction just mentioned, by causing the reoxidation of the calcium into lime. This is precisely what would happen in a Bessemer converter or in an open hearth furnace; and it is for this reason that in these processes the sulphur cannot be removed by the deoxidation method just mentioned. The advantage of that method is shown by a comparison of the practical results. With the open hearth process there is much difficulty in bringing the percentage of sulphur down to 0.03 per cent, and still more difficulty in reducing it to 0.02 per cent, whereas with the electric furnace it can readily be brought down to less than 0.01 per cent.

After the desulphurization has been carried to the point desired, the deoxidizing slag is removed, carrying the calcium-sulphide, which, while almost insoluble in the metal, is easily soluble in the slag. The finishing touches are given to the metal by adding whatever is necessary to give the metal the composition and properties desired; and the metal is then emptied out into ladles for use in making ingots or castings.

If desired, the whole series of refining operations above mentioned may be repeated on the molten metal before taking it out. This refining by repetition of the process may be necessary in cases where the phosphorus and sulphur were present in unusually large quantity or where a very high degree of refining is to be attained.

Destruction of Concrete Foundations.

Cement foundations of buildings are endangered not only by free sulphuric acid, but also by the soluble sulphates of calcium and magnesium. According to W. Thörner, peat soils contain only small and harmless amounts of these sulphates; moorlands near the sea may, however, be richer in them. The reason of the destructive action of the soluble sulphates is, according to H. Kuhl—compare Zeitschrift fur Angewandte Chemie, 1916, pages 335 and 363, for both these papers—that a voluminous compound of the formula $3CaO,Al_2O_3,3CaSO_4$ (Candlot and Michaelis) is formed, when soluble sulphates penetrate into cements, whose sulphate percentage was originally unobjectionable.

Insulating Oils and Dust.

Everybody understands that all dust has to be kept out of insulating oils, says "Engineering." But it would hardly have been suspected that the process of cleaning the electrodes with cotton cloth may actually make matters worse, because it is liable to introduce dangerous dust in the shape of fine cotton fibres. Such is the case, according to the researches of Messrs. T. Hirobe, W. Ogawa and S. Kubo, of the Electrotechnical Laboratory of the Department of Communications, Tokyo (Report No. 25 of the 3rd Section of the Laboratory). The experiments—oil-insulation tests—were conducted in a glass cylinder of a capacity of 25 cu. in., in which the electrodes, brass balls, pointed wires, discs, etc., could be adjusted as to distance apart, and be easily removed for cleaning. When a potential difference is established between the electrodes in oil, any dust particles present tend to arrange themselves in a chain bridging over the electrode gap, and the fine cotton particles adhering to the electrodes produce sufficient dust, the experimenters found, to lower the breakdown kilovolts to one-third of their previous value. For these reasons they recommend the following mode of cleaning the electrodes in testing apparatus of their type. Immerse the cleaned electrodes in the oil, adjust the distance, and apply the highest possible potential for several minutes; the dust will concentrate in the gap. Wash the electrodes in the oil, take the oil out of the cup, and wash the vessel by stirring the oil in it. Charge the cup again, insert the electrodes, and repeat the process; all with due caution, of course. It was observed that the discharge passed most readily between a point and a disc; contrary to expectations, however, the breakdown voltage between two discs was considerably lower than that between two spheres. Heating the oil is generally supposed to increase the dielectric strength. According to the experimenters this increase is more apparent than real, and probably due to the partial drying of any fibrous hygroscopic substances in the oil; according to F. W. Peck the dielectric strength ought to diminish on heating, and the Japanese workers are inclined to agree with that statement. The effect of moisture they consider slight as long as dust is absent. Oils dissolve very little water, only about 0.01 per cent; with greater amounts of water oil forms emulsions, the particles agglomerating sooner or later. If water particles settle on the insulators, e. g., on a high-tension coil, immersed in the oil, their effect may be disastrous. Dust particles, especially when fibrous, absorb the moisture; such fibres, it was found, readily bridged the electrode gap and caused breakdown. Thus the breakdown voltage of a good oil occurred at from 90 to 60 kv., with a gap of 150 mils., as the moisture increased; when the electrodes were "cleaned" by being rubbed with a dry cotton cloth a similar curve was obtained, but the breakdown occurred at from 35 to 15 kilovolts. In a high-tension transformer the dust is attracted toward the high-tension coil and accumulates on it; in such cases, it was noticed, a single fibre might suffice to cause disruptive discharge. Fortunately filtering through a proper press removes both moisture and dust, and it is recommended to keep the oil of high-tension transformers in constant circulation with the aid of filter presses.

Pneumatic Conveyor for Slack.

The principle of the pneumatic conveyor, introduced (for grain) some 30 years ago by Duckham, has since been applied to other granular materials, including slack, owing to its convenience, the absence of dust, small space and little attention required. An installation of this type has recently been set up, at the works of the Deutsche Solvay Company, Bernburg, for discharging fine-grain brown coal from railway cars, which is accomplished at the rate of 15 tons per hour without dissemination of dust, and without leaving any reminder to be removed by hand.

An iron mast, set up by the railway track, supports a movable conveyor pipe by means of a jib. This pipe can be slewed, and can be moved up and down by means of a winch at the foot of the mast. The suction nozzle terminating the pipe is guided to and fro by hand. From the mast, the conveyor pipe passes to a hopper, which is of large dimensions on account of the low specific gravity of the brown coal; and this hopper communicates with a second one (to the right), in which the dust arising from the coal is deposited. The mouths of both are closed by pocket-wheel valves which are kept in constant rotation to discharge the contents of the hoppers. A vertical air pump communicates with the conveyer pipe through the hoppers; and the discharged air is passed through a system of bag filters before being expelled into the atmosphere by a fan. A worm conveyor, underneath the valves, delivers the coal to the fires. The same type of device might also be applied to the removal of ash and flue dust from producers, blast furnaces, etc.—Stahl and Eisen.

Belt Conveyors.

R. Trautschold. in "The Engineering Magazine," says:—Material supplied in an adequate and continuous stream can be handled more expeditiously by the belt conveyor than by any other form of material-handling equipment. For handling loose material a troughed belt is required, and, though the load can be supported by a foot of belt is not great, the capacity of even a narrow belt is surprisingly high, owing to the speed at which a belt may be run. For instance, under perfect loading conditions, a belt conveyor only 12 inches wide can handle nearly 90 tons of sand per hour, while one 36 inches wide has a capacity of 800 tons per hour when run at a speed of 375 feet per minute.

Considering a specific belt conveyor installation. one handling 85,000 tons of fine coal per year may be taken as typical and well illustrating the economic value of the device. Such a conveyor, 500 feet long, elevating the load 30 feet in its travel, and distributing it to an overhead bunker 100 feet in length, would not be an unusual installation. With power delivered to the conveyor drive costing 2 cents per horsepower, the net operating cost per ton, including all charges, is 1.957 cents with pin-bearing idler and 1.629 cents with roller-bearing equipment.

INDUSTRIAL SAFETY

COMPARISON OF WORKMEN'S COMPENSATION LAWS.

In the rapid spread of workmen's compensation legislation in this country the fact is often overlooked that many of the laws adopted are far less comprehensive than their mere titles would indicate. Because 35 States and Territories, with some 75 per cent of the employed population, have adopted such laws it is frequently assumed that a similar proportion of the wage workers of the country are now fully and properly insured against the loss and suffering of industrial accidents. That this is not true is emphasized in Bulletin No. 203 of the Bureau of Labor Statistics of the United States Department of Labor, entitled "Workmen's Compensation in the United States and Foreign Countries."

The bulletin presents a detailed comparison of the principal features of the various State compensation laws. The comparison brings out most striking differences, particularly as regards the proportion of workers covered and the scale of compensation benefits. No State compensation act covers all employes. In the first place most of the acts are elective. Employers who do not accept are penalized, but in spite of this there are always a number who refuse to elect. In the second place, all of the acts purposely exclude certain classes of employes. Thus, agricultural workers, domestic servants and casual employes are almost everywhere excluded. Also there is an important group of acts which apply only to a list of employments declared to be especially hazardous, although in practice they may be no more hazardous than others not included. Again, a considerable number of acts apply only to employers having less than a certain number of employes, the minimum being in one case as high as 11.

The result of these limitations and exclusions is to restrict the benefits of compensation very often to only a rather small fraction of the total number of workers. The bulletin makes a rough estimate of the proportion covered in each State, the estimate being based on the liberal assumption that election has been made by all employers affected in States having elective laws. In only two instances, New Jersey and Hawaii, do the acts include at best as many as 90 per cent of the total workers and only 7 States cover 80 per cent or over. One covers less than 20 per cent and 9 less than 50 per cent.

Similarly striking are the differences between the several acts as regards the benefits paid in case of injury. A few extreme instances may be cited. Thus, in the case of a fatal injury occurring in the State of Oregon the widow and children may receive in total as much as $13,480, whereas in Vermont the maximum would be $1,830 and under the Oklahoma act no benefits at all are paid in case of death. For loss of a hand the Alaska act may pay as much as $2,640, while the maximum for the same injury in Colorado is but $780. Again, in Oregon and Porto Rico cash benefits are paid for injuries of no matter how brief duration, whereas in Colorado no cash benefits are paid for disabilities of less than 3 weeks. Further, Washington and Wyoming, at one extreme, make no provision for medical service, this expense falling entirely on the worker, whereas, at the other extreme, several States, as Connecticut, Massachusetts and California, may pay for all necessary medical and hopital service, without limit as to time or amount.

The words "accident" and "injury" have different meanings in different places. Generally speaking, the practice has been to limit compensation to accidental injuries in the strict sense. There is a tendency, however, to broaden the term so as to take in the more subtle injury of occupational disease, such as lead poisoning, wood alcohol blindness and anthrax. Massachusetts is the only State in which this has been regularly done and approved of by both the administering board and the courts. But the California act was recently amended so as to include occupational diseases and in certain other States the commissions have so interpreted the law only to be overruled by the courts.

It appears, therefore, that practically all of the State compensation acts now in force need enlarging and liberalizing before they can be regarded as furnishing adequate protection to the whole body of wage earners. This, the bulletin points out, has been a general tendency of recent amendments. In no case has a compensation system once introduced been repealed. But in a number of instances inferior acts have been superseded by better ones and in all cases where the courts have held particular acts unconstitutional the States affected have proceeded to enact new laws that would meet the necessary legal tests and, if no other way offered, the constitutions have been amended.

At the beginning of 1917 there were 35 compensation laws in effect in the United States, including those of Hawaii, Alaska and Porto Rico, but not including the new Federal act of 1916, which was not yet in operation, due to delay in the appointment and confirmation of the commission. Of the 17 non-compensation States, 10 are in a single group of southern and south central States—Virginia, North Carolina, South Carolina, Georgia, Florida, Alabama, Mississippi, Tennessee, Arkansas and Missouri. The other 7 are the two Dakotas; the three mountain States of Idaho, Utah and New Mexico; Delaware and the District of Columbia. In several of these, investigating commissions are now at work and in some it is probable that compensation acts will be adopted at the current sessions of their legislatures.

In addition to reproducing in full the text of the American laws now in force the bulletin summarizes the important features of the laws of foreign countries. It also presents a comprehensive analysis of the decisions of the courts and of the various administrative commissions.

STATEMENT OF OWNERSHIP, MANAGEMENT, ETC., OF
The Blast Furnace & Steel Plant

[Required by the Act of Congress of August 24, 1912]

Name of Publication: **The Blast Furnace and Steel Plant**, published monthly, at Pittsburgh, Pa. [Report for April 1, 1917.]

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Managing Editor—Herbert A. Andresen, 108 Smithfield street, Pittsburgh, Pa.

Business Manager—Adam W. Tritsch, 108 Smithfield street, Pittsburgh, Pa.

(Names and addresses of stockholders holding 1 per cent or more of total amount of stock):

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L. L. Carson, Pittsburgh, Pa.
E. E. Phelps, Pittsburgh, Pa.
R. E. Densmore, Detroit, Mich.
Mary A. Howe Estate, Pittsburgh, Pa.
Adam W. Tritsch, Pittsburgh, Pa.

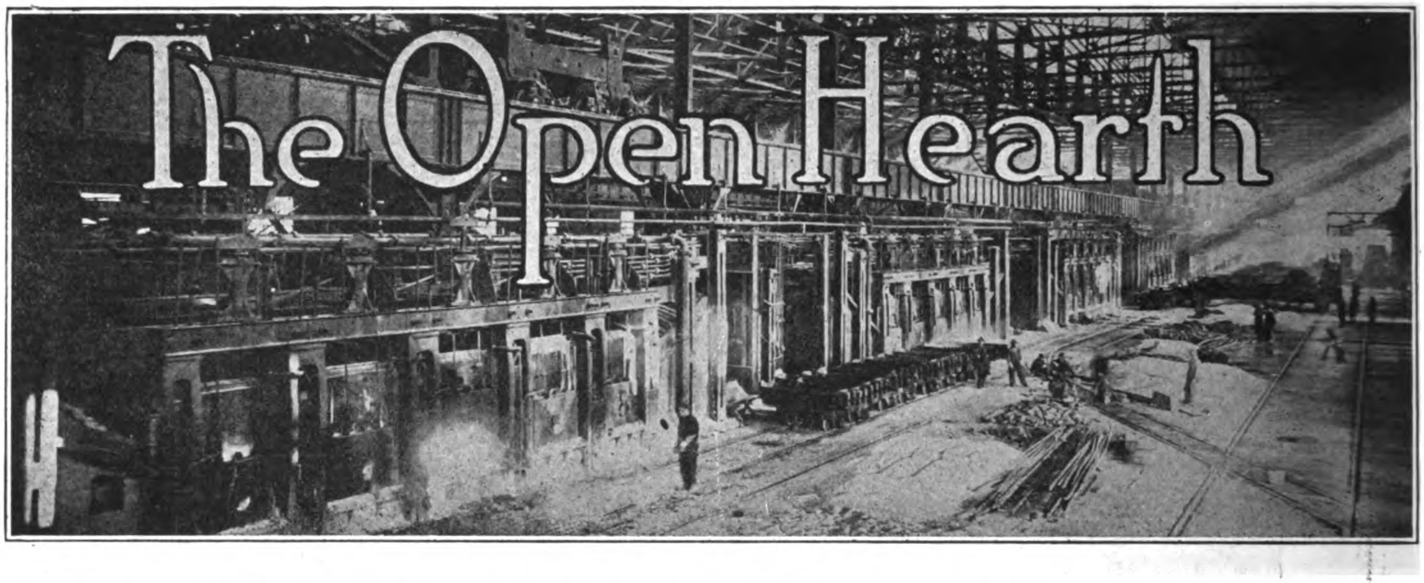
Known bondholders, mortgagees, and other security holders, holding 1 per cent or more of total amount of bonds, mortgages, or other securities: None.

HERBERT A. ANDRESEN, Managing Editor.

Sworn to and subscribed before me this 19th day of March, 1917.

JOHN N. ENGLISH, Notary Public.

(My commission expires March 9, 1919.)



The Open Hearth

C. S. Arms, assistant superintendent of the open hearth plant of the John A. Roebling's Sons Company, Trenton, N. J., has resigned to become associated with the Wright Wire Company, Worcester, Mass.

V V

T. G. Ayres, formerly assistant superintendent of Edith furnace of the Carnegie Steel Company, N. S.. Pittsburgh, is now doing special blast furnace research work for the Jackson Iron & Steel Company, Jackson, Ohio.

V V

C. J. Bacon, assistant steam engineer for the South Works, Illinois Steel Company. South Chicago, Ill., has resigned to become associated with the engineering department of the E. I. du Pont de Nemours Company, Wilmington, Del.

V V

Thomas S. Brenholtz, chief engineer of the Penn Iron Company. Lancaster, Pa., was formerly master mechanic for the American Iron & Steel Manufacturing Company, Lebanon, Pa.

V V

John Penn Brock, vice president of the American Iron & Steel Manufacturing Company, Lebanon, Pa., has been made general manager of that plant since its absorption by the Bethlehem Steel Company.

V V

Palmer C. Collins, assistant superintendent of the South Works of the American Steel & Wire Company, Worcester, Mass., has resigned.

V V

J. V. Culliney, for sixteen years superintendent of the American Iron & Steel Manufacturing Company, Lebanon, Pa., has become identified with the Penn Iron Company, Lancaster, Pa.

V V

Charles B. Cushwa, superintendent of the Youngstown Iron & Steel Company, Youngstown, Ohio. will be general superintendent of the plant under the management of the Sharon Steel Hoop Company.

V V

Francis Bird Dutton, now in charge of the technical work of the American Grondal Company, 120 Broadway, New York City, was formerly general manager of the Lebanon, Pa., plant of the Pennsylvania Steel Company.

V V

E. P. Everhard, mill engineer for the Phillips Sheet & Tin Plate Company, Weirton, Pa., served as assistant to W. T. Martersteck, consulting engineer, Chicago, Ill., until his resignation to accept his present position.

V V

H. H. Foote, superintendent at the Dover, Ohio, plant of the Penn Iron & Coal Company, has been made general superintendent of the furnaces of the United Iron & Steel Company at Leetonia, Ohio and West Middlesex. Pa.

V V

J. H. Gledhill is now assistant general superintendent for the Wharton Steel Company, Wharton, N. J. He was formerly with the Worth Brothers Company, Coatesville, Pa.

V V

Comer D. Hazen, formerly electrical engineer with the American Steel Foundries, Chicago, Ill., is now industrial power engineer with the Danville Street Railway & Light Company, Danville, Ill.

V V

Prof. Henry M. Howe has been awarded the John Fritz Medal for 1917 on account of his investigations in metallurgy, especially in connection with his investigations and research in the metallography of iron and steel.

V V

C. H. Hunt, who has been connected with the William Tod Company, Youngstown, Ohio, for several years as chief engineer, has resigned to become chief constructing engineer for the Phillips Sheet & Tin Plate Company, Weirton, W. Va.

V V

Harry S. Hunter on March First resigned his position as Pittsburgh manager for the Chicago Pneumatic Tool Company to become active president of the Hunter Saw & Machine Company, Pittsburgh.

V V

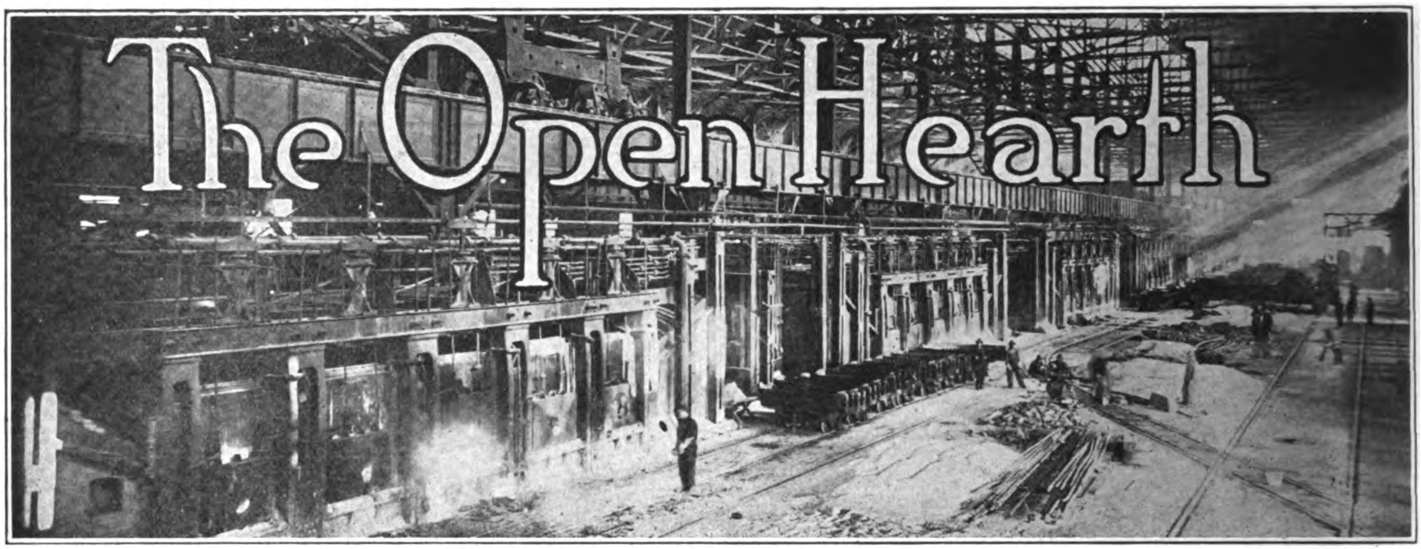
John C. Jay, Jr., former vice president of the Pennsylvania Steel Company, who resigned to become chairman of the Maxwell Motor Company, has left that field to become junior partner in a firm of consulting engineers, to be known as Jamieson, Houston, Graham and Jay, New York City.

V V

William J. Kaup has become chief engineer of the ordnance department of the Crucible Steel Company of America, Newark, N. J.

V V

William Langdon is now assistant purchasing agent for the Willys-Overland Company, Toledo, Ohio. in charge of the buying of steel and other metals. He was formerly with the Hayes Wheel Company, Detroit, Mich., and previous to that with the Michigan Stove Company, also of Detroit.



The Open Hearth

W. H. Magie has been made superintendent of the new Morgan Park hospital of the Minnesota Steel Company, Morgan Park, Minn.

V V

J. William Middendorf, since its reorganization president of the Alabama Coal & Iron Company, is now president of the Alabama Company, superseding the former concern, with general offices at Birmingham, Ala.

V V

H. T. Morris is now superintendent of the projectile department of the Bethlehem Steel Company, South Bethlehem, Pa.

V V

Lawrence J. O'Loughlin, recently blast furnace engineer of the Cambria Steel Company, Johnstown, Pa., is now chief engineer for the Wharton Steel Company, Wharton, N. J., recently acquired by J. Leonard Replogle, former vice president of the Cambria Steel Company.

V V

Reese M. Price has been appointed chief clerk of the Youngstown Sheet & Tube Company, vice W. Meub, transferred.

V V

C. H. Rose, for the past five years auditor of the Brier Hill Steel Company, Youngstown, Ohio, has been appointed secretary to the president.

V V

Francis C. Ryan, superintendent of the Midland Recoveries Company, Hammond, Ind., has been made chief electrometallurgist of the U. S. Bureau of Mines, Washington, D. C.

V V

D. H. Schaeffer, now in charge of the laboratories for the United Iron & Steel Company, West Middlesex, Pa., was formerly located at Dover, Ohio, with the Penn Iron & Coal Company in a similar position.

V V

C. E. Sharp is now master mechanic for the Lukens Steel Company, Coatesville, Pa. He was formerly master mechanic for the Midvale Steel Works.

V V

William Smith, formerly general master mechanic for the Pennsylvania Steel Company, Steelton, Pa., has been made general master mechanic for the Worth Brothers Company, branch of the Midvale Steel & Ordnance Company, Coatesville, Pa.

V V

Fred W. Steinen, purchasing agent and in charge of ore supplies for Corrigan, McKinney & Company, Cleveland, has resigned, and probably will enter business for himself in Cleveland.

V V

Lawrence H. Stone, former assistant superintendent of the Richard Mine of the Thomas Iron Company, Wharton, N. J., has become superintendent, vice Albert L. Robb, resigned.

V V

R. S. Shoemaker, recently electrical engineer for the St. Lawrence and Dominion Bridge Company, Montreal, Canada, has become superintendent of maintenance for the American Rolling Mill Company, Middletown, Ohio, vice J. H. Wilson, promoted. Previous to taking up his work in Canada in 1909, he was electrical engineer for the Pittsburgh Steel Company, Pittsburgh, Pa., leaving that post to become electrical engineer for the Algoma Steel Company, Sault Ste Marie, Ontario; from which latter position the work recently resigned with the Dominion Bridge Company was taken up.

V V

J. L. Swayze has been made manager of the bolt and nut plants of the Bethlehem Steel Company, formerly a part of the American Iron & Steel Manufacturing Company, Lebanon, Pa., of which company he was formerly manager of the Reading plant.

V V

A. J. Sweeney, who has been assistant purchasing agent for Corrigan, McKinney & Company, Cleveland, Ohio, has been made purchasing agent in charge of ore supplies, vice F. W. Steinen, resigned.

V V

W. E. Wolfram, who has been superintendent of the projectile department of the Bethlehem Steel Company for the past eleven years, has severed his connection with the company and plans to take a rest before engaging in other manufacturing work.

V V

Walter H. Wood, superintendent of power plants for the Baltimore & Ohio Railroad, has resigned to become associated with the Combustion Engineering Corporation, New York City.

Some Pointers on By-Product Coke Oven Operations

In discussing the recovery of benzol from gas, as a paper before the American Institute of Chemical Engineers, F. W. Sperr, Jr., chief chemist of the H. Koppers Company, described the operation of a benzol recovery plant in connection with a by-product coke plant as follows:

In discussing the operation of a benzol recovery plant of modern type I shall deal principally with the Koppers patented process, because I have made a rather special study of this patented process as being typical of modern practice. To the best of my knowledge all of the coke oven benzol plants now under construction in America, with possibly one or two exceptions, are of this type.

In America the wash oil generally used to absorb the wash oil is a petroleum product usually known as straw oil, of which at least 90 per cent should distill between 250 and 350 degrees, C. A good absorbent oil has a specific gravity of less than 0.88 at 15 degrees, C. and is readily fluid at 4 degrees, C. It contains no naphthalene or pitch and exerts a good solvent action on benzol. In best practice the amount of benzol absorbed (technically the "enrichment") is kept between 2 and 3 per cent of the absorbing oil. Too high enrichment is likely to lead to loss of benzol, and too low enrichment may involve needless consumption of absorbing oil. In European practice heavy tar oils are used almost exclusively as absorbing and steam media and such materials may find increasing application in America. Such tar oils should contain less than 7 per cent naphthalene and 90 per cent of the material should distill between 200 and 300 deg. C.

Let us follow the flow of the gas through the process, and then that of the oil. Previous to treatment with the absorbing oil, the gas should be cooled to a suitable temperature which may vary from plant to plant and depends principally upon such factors as its moisture and naphthalene content, temperature of the wash oil, and per cent enrichment desired. This cooling is accomplished by means of the cooler which is preferably of the direct contact type. The water not only acts as a cooling medium, but mechanically washes a large portion of the naphthalene out of the gas and carries it into the separating sump. The cool gas then passes into the benzol washers. These are tall scrubbing towers of the hurdle type, effecting a very intimate and prolonged contact between gas and oil. The debenzolized gas passes out of the last washer through the return main to its point of consumption.

The fresh wash oil is pumped from the circulating tank over the scrubbers in an opposite direction to the flow of the gas, maintaining the counter-current principle that should be adopted in nearly all scrubbing operations and bringing the fresh washing medium into the scrubbing system at a point where the gas contains the least light oil vapors. The distribution of the wash oil over the tops of the scrubbers is a very important matter, and should be done as uniformly as possible. The enriched wash oil accumulates in tanks usually located underneath the scrubbers, and is pumped from these to the benzol recovery plant to be heated for the purpose of releasing its benzol constituents.

Part of this heating is accomplished in the Koppers system by the utilization of the heat in the hot debenzolized wash oil leaving the still. Two heat economizers are used in this system. The cold oil first enters the heat exchanger, where it is heated by benzol vapors and steam from the still, thence it is conducted to a second heat exchanger, where it receives additional heating by means of hot debenzolized wash oil leaving the still. It is then still further heated to the maximum temperature desired by means of live steam in a superheater, from which it passes into a still, this still is composed of a series of superimposed sections or chambers as in common distillation practice. The heated oil flows down through these sections while steam is blown directly into the lowest section and travels in a direction opposite to that of the oil. The mixture of benzol and water vapor is partially rectified in the upper portion of the still, and then enters the heat exchanger as mentioned before, where it is condensed and the partial preheating of the enriched wash oil is effected. The remaining vapors are completely condensed and the total condensate cooled in a water-cooled condenser. The light oil is separated from the water in the condensate by means of a separator.

The debenzolized wash oil after leaving the still passes through the heat exchanger, where it gives up a part of its heat to the enriched wash oil, as stated above. Then it is finally cooled in the water cooler. The cool oil is then delivered to circulating tank, thus completing the cycle.

The improvements that have been made in recent practice have to do principally with effecting as great economy as possible of heat in the cycle of gas treatment, distillation and cooling through which the wash oil passes. In the Koppers system it is calculated that the devices for heat economy reduce the steam consumption in distilling the enriched wash oil by more than 80 per cent; 1,000 gallons enriched oil 77 to 284 deg. F.; (1,000 × 7.3 × .537 × 207) = 811,440 B.t.u. = 840 lb. of steam at full pressure, or, per 1,000 gal. purified benzols, 55 × 840 = 46,200 lb. of steam which, at 2 cents per 100 lb., costs $9.24; of this steam, heat exchanger cooling the hot debenzolized oil from 275 deg. to 170 deg. F. in preheating the enriched oil, saves per 1,000 gal. enriched oil (973 gal. debenzolized oil), 973 × 7.3 × .54 × 105 = 402,675 B.t.u. = 417 lb. of steam or 49.8 per cent of the total; heat exchanger heating the cold, enriched oil by the benzol vapors and steam from the still, adds a recovery of about 256,000 B.t.u. per 1,000 gal. wash oil, equivalent to 265 lb. of steam or 31.5 per cent of the total; in the two heat exchangers, therefore, the total saving is 417 + 265 = 682 lb. of steam per 1,000 gal. of enriched wash oil circulated, or 37,510 lb. of steam for every 1,000 gal. of purified benzols produced, and the cost of steam for this purpose is reduced from $9.24 to $1.72 per 1,000 gal. of product.

Further economy lies in the saving of cooling water circulation which would be required to cool the debenzolized wash oil.

The light oil is accumulated in a drain tank and portions are taken for distillation in the still. This still is usually known as the crude still, the first distillation of the wash oil being made for the purpose of effecting an approximate separation of several fractions of different boiling points preliminary to washing and final rectification. This and subsequent distillations are made intermittently in stills of large capacity (6,000 to 12,000 gallons) which give better fractionations than are possible in smaller apparatus. The continuous type of stills has not been found satisfactory in this type of work. The crude still does not require the elaborate dephlegmator that is necessary on the final rectifying stills. The heating is accomplished by means of internal steam coils and a direct steam spray. The benzol and toluol are principally distilled off by indirect heat, using the steam coils, and the higher boiling constituents.

NEWS OF THE PLANTS

The April meeting of the Pittsburgh section, Association of Iron & Steel Electrical Engineers, will be held at the Fort Pitt hotel, Saturday, April 21st, under the auspices of the standardisation commitee, W. T. Snyder, chairman.

The Pacific Steel Company Seattle. Wash.. is having an open hearth plant, to increase its daily capacity 150 tons, installed there to provide additional steel for the company's line of steel products.

The H. Koppers Company, Pittsburgh, plans to move its offices from the present quarters in the First National Bank Building to the Frick Arcade, between April 15th and May 1. The new location will take an entire floor of the new arcade building, and a portion of another.

The eleventh annual convention of the Association of Iron & Steel Electrical Engineers will be held in Philadelphia, September 10th to 14th, inclusive. A. H. Swartz, 10704 Churchill avenue, Cleveland, Ohio, is chairman of the convention and entertainment committee.

The Pittsburgh Iron & Steel Foundries, Midland, Pa., is rebuilding its power plant and has retained Barton R. Shover, 704 Diamond Bank Building, Pittsburgh, as consulting engineer in connection with power problems and applications.

The Bacharach Industrial Instrument Company, formerly located at 14 Wood street, Pittsburgh, has moved into larger quarters, at 422 First Avenue, where the company is prepared to handle the increasing volume of business for gas meters, pressure recorders, etc.

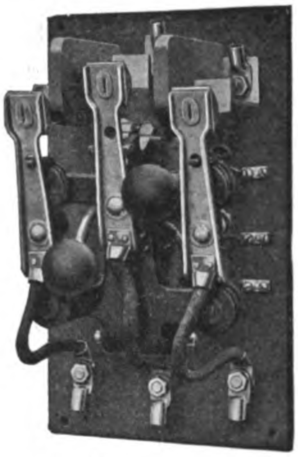
Effective April First, the Shepard Electric Crane & Hoist Company, Montour Falls. N. Y., through its general manager, F. A. Hatch, announces a ten per cent raise in the hourly rate of wage, while at the same time the hours of labor per day will be reduced from ten to nine hours with a half-holiday, as heretofore, on Saturday.

The Homestead Valve Manufacturing Company, Homestead, Pa., announces the appointment of the following companies to have exclusive representation of the Homestead quarter-turn cock and the Hovalco angle blow-off valve in their immediate vicinities: Queen City Supply Company, Cincinnati, Ohio; Root, Neal & Co., Buffalo, N. Y. These representatives carry a large stock of Homestead valves on hand at all times, and are in a position to quote on all lines of Homestead manufacture.

The Ingersoll-Rand Company, 11 Broadway, New York City, has recently issued two new catalogs on dry vacuum pumps, Form No. 3037 covering the straight line type and Form No. 3038 on the duplex type. Both machines are equipped with Ingersoll Rogler Valves, are capable of maintaining a high vacuum and will handle discharge pressures of several pounds. The maximum degree of vacuum possible varies with the different machines, to within .6 inches of the barometer. Pumps are offered in steam and power driven types in a large range of sizes and capacities as listed in the catalogs. Catalogs are profusely illustrated in colors to show the machines in whole and in section. Copies free on request to the nearest branch office of the company.

The Whitaker-Glessner Company, Wheeling, West Virginia, which has been a principal stockholder in the Wheeling Corrugating Company, also of Wheeling, for several years, has taken over all business of the company, and will operate it as a department of the holding company, and known as the Whitaker-Glessner Company, Wheeling Corrugating Department.

NEW C-H REMOTE CONTROL SWITCHES.



The accompanying illustration shows the new C-H Remote Control Switch made in single, double and triple pole types by The Cutler-Hammer Manufacturing Company, of Milwaukee. The design is such that current is consumed only at opening and closing—a mechanical latch holding the contacts closed after the switch contacts are closed by magnetic force. The use of this switch is thus very economical of current. The same type of contact fingers are used as on other C-H control apparatus, many types of which, such as drum crane controllers must stand the most severe service. The contacts are cold rolled copper and are kept clean by a wiping motion in closing. Two solenoids are used, one for closing and one for opening the switch. The solenoids are energized by circuits connected to push button control switches which may be placed where desired. These new switches are of 100 ampere capacity and made for both alternating and direct current circuits. They are particularly suited for the control of lighting circuits from a distant point or central location. In large buildings, factories, theatres, etc., remote control saves needless use of current and makes unnecessary the running of the circuit wires over long distance to a desirable control location. On burglar lighting systems the remote control switch is also used to advantage.

The Aetna Iron & Steel Company, Ltd., of which Joshua Kingham is president and S. M. Officer secretary and treasurer, has tranferred its office holdings from former quarters at Victoria, B. C., to 916 Standard Bank Biulding, Vancouver, B. C. The company has a rolling mill with 12- and 21-inch trains and reheating furnace capacity therefor. An open hearth plant will be built, together with other facilities.

We have received from the United Engineering & Foundry Company, Farmers Bank Building, Pittsburgh, copy of Bulletin I, wherein is portrayed the advance in the rolling mill industry of America, and which shows scenically, recent installations of United products. The bulletin is essentially a collection of mill photographs, and as such is especially valuable in showing the layout and arrangement of the more noted plants equipped by the United Engineerig & Foundry Company. We also have Bulletin S1 which describes and illustrates hot and cold saws for metal cutting, which gives much valuable information on the layout and maintenance of saw tables and the handling of metal saws. Either will doubtless be sent on application.

The H. W. Johns-Manville Company has located its Louisville, Ky., branch at Fourth Avenue and Guthrie Street. The office is in charge of A. H. Voigt.

The Gibb Instrument Company, 1105 Highland Building, Pittsburgh, on April First will move to 5716 Euclid Avenue, Cleveland, Ohio, where equipment is being installed in a new Laboratory which will materially increase the company's capacity and afford means for meeting delivery dates in its scientific apparatus. The officers of the company are W. H. Gibb, president; H. L. Clark. vice president; and J. R. Brueckner, secretary and treasurer.

"BLAST-FURNACE CONSTRUCTION IN AMERICA."

J. E. Johnston, Jr., consulting engineer on blast furnace construction and operation, has put into book form. and had published by the McGraw-Hill Book Company, New York, the series of articles on blast furnace construction and operation which appeared in several numbers of "Metallurigical and Chemical Engineering," the title of the book being "Blast-Furnace Construction in America." Beginning with a brief introduction of the needs for a blast furnace and the conditions which have led up to the present iron-producing unit, characteristics of fuel and other operating features are covered, together with the effect of various elements on the ultimate composition of the pig iron. Chapters of the book proper take up handling the raw materials; filling the blast furnace, with a discussion of various furnace tops and their effect on stock distribution and maintenance of the stock line. The boiler plant, as furnishing the first use of blast furnace by-product in the form of the surplus gas, is treated next, with a critical comparison of the various types of boilers arapted to use in stack installations. Following the generation of power comes a review of blowing engines and air requirements, leading up to the discussion of hot-blast stoves and their peculiarities. Construction of the furnace and the most advantageous arrangement of units is next taken up and various types of stacks compared. Cleaning and washing the gas and the dry blast are handled in two separate chapters, with recommendations. The handling of hot iron and cinder is covered, followed by a chapter on auxiliaries and general arrangement of the plant. The book is illustrated throughout with operating views and charts, and is a thorough covering of the subject in the compass allowed by the 405 pages utilized. The book will be sent postpaid for $4.00.

MAGNETIC CONTACTOR CONTROLLERS FOR MILL SERVICE.

Efficiency, economy, and safety are operating features most desired by superintendents of iron and steel mills, and perhaps nothing has been more potent in obtaining these features than the modernization of the various processes in the mills.

One limiting feature of motor drives for steel mill service in the past has been the effectiveness of the control apparatus. The processes involved are such that continuity of service must be maintained at all times; a failure may result not only in loss of expensive material and shutdown of the mill, but also in the sacrifice of human lives. It therefore becomes necessary to furnish control apparatus that will bring out the highest efficiency of the motors, and at the same time be so simple and sturdy that there will be no possibility of the work.

A study of the different operations by which the ingots are reduced to blooms and subsequently to rails, channels, and other finished products will show the severe conditions imposed upon the motor and the control apparatus.

Take for instance the screw-down of a two-high reversing mill, where motors are used to adjust the draft by raising and lowering the top roll. This is done for each pass while the steel is on the receiving table and the rotation of the rolls is being reversed. The time for adjustment is usually less than two seconds, as an ingot must be reduced to bloom in two minutes, makes nineteen passes in that time. Another example of severe operation may be found in the reversing tables of a two-high reversing mill. These tables consist of a set of small rolls, geared together, operated about half as often as the screw-down. The ingots which are handled by these tables weigh approximately two and a half tons, and come from the rolls with a velocity of from 500 to 700 feet per minute. In a period of about two seconds after the ingot has come from the rolls, these tables must stop, reverse, and accelerate in the reverse direction, and return the ingot to the rolls. The severity of this operation may be understood better if it is considered that one of these tables is usually made up of 22 rolls, each of which weighs half a ton.

The engineers of the Westinghouse Electric & Manufacturing Company working at first hand on the problem of proper control, discovered that in most instances where trouble occurred in the manually operated motor-driven processes. it was due to the operator's lack of complete knowledge of the principles underlying motor operation, or to his lack of skill in applying these principles. Consequently their first step was the elimination of any need for skill on the operator in starting the motor. With the type C magnetic contactor controllers the personal equation of the operator has been eliminated. The operator simply pushes the button or moves the handle of his master switch and the motor starts with entire independence of the operator. Not only is the human factor eliminated, but it has been replaced by a mechanism which starts the motor with scientific correctness, obtaining the utmost efficiency from it. Thousands of starts may be made, and each with the same maximum efficiency.

This one feature of automatic acceleration has been the means of saving many thousands of dollars on the machines which are so equipped. It is also very much easier for the operator to handle his apparatus, particularly in the case of cranes and similar service. In this work there are usually three or more different motors; consequently as many controllers must be handled by the operator, and at some times almost simultaneously. While this is an almost impossible task with manually operated controllers it can be done very easily by means of the Westinghouse type C magnetic contactor controllers, the automatic features of which permit extremely accurate control of the crane.

After eliminating the operator as a source of trouble, the next step in the solution of the problem was to design and build a controller that would not only do the work of automatically accelerating the motor, but at the same time be so simple and sturdy that there could be no chance of a break in the continuity of the controller.

These type C controllers are made up of magnetic contactors and relays. each of which is mounted on a separate slate base, the whole being assembled on a framework of iron pipe. The number of parts has been reduced to a minimum and those which are necessary are built very ruggedly. to withstand the severe conditions imposed on the controller. The grid resistors used are mounted separately from the controller itself, thus making it extremely easy to inspect the apparatus or change the contactors, which may be required at long intervals.

RECENT PATENTS

The following patents are reported expressly for The Blast Furnace and Steel Plant, by E. G. Siggers, patent attorney, Suite No. 31, National Union building, Washington, D. C., from whom copies of any one of the patents may be obtained by sending fifteen cents in stamps.

Joseph E. Johnson, Jr., of New York, N. Y., has invented improvements in composition of cast iron, No. 1,217,184, dated February 27, 1917. This invention relates to an improved composition of cast iron, more particularly cast iron produced by the coke process, the object of the invention being to give the desirable qualities of strength, density of grain and chilling properties, to the more inexpensive cast irons, such as are produced by the coke process of smelting and to other irons which do not possess such qualities, these qualities being now exclusively possessed by the more expensive high-grade cast irons, such as are produced by the charcoal process of smelting. The improved composition consists of coke iron containing controlled quantities of oxygen, carbon and silicon, so combined as to impart strength, density of grain and chilling properties to the composition.

William C. Coryell, of Youngstown, Ohio, has invented improvements in metal-handling apparatus for rolling mills, No. 1,217,919, dated March 6, 1917. This invention relates to apparatus for use in handling and conveying metal in connection with rolling mills and has to do more particularly with apparatus for shifting the pieces of metal between passes of the mill so that each piece will be properly worked and shaped. The apparatus comprises a plurality of substantially parallel rollers operative to receive the pieces of metal being put through the mill, a work-engaging face on one of said rollers and work-engaging means coöperating with said face to change the position of any such piece on said rollers, the work-engaging face on said roller extending above the surface of the roller and having its highest work-engaging points extending around said roller, the distance of said points from the axis of said roller varying gradually from a minimum to a maximum and the distance of said points from a plane at right angles to said axis likewise varying gradually from a minimum to a maximum.

The following patents are reported expressly for The Blast Furnace and Steel Plant, from the patent law offices of Norman T. Whitaker, of Legal building, Washington, D. C., (opposite United States patent office) from whom copies of any one of the patents may be obtained by sending fifteen cents in stamps.

A ring-roll mill has been invented and patented as No. 1,217,525, by Edgar B. Symons, of Milwaukee, Wis. The claims of his patent are forty in number.

James J. Rhinelander, of Pittsburgh, Pa., has just been granted a patent No. 1,217,503, on a roller-chain pipe-grip.

Edwin T. Greenfield, of Kiamesha, N. Y., has invented art of metal working, bearing patent No. 1,217,748, in which substantially the following is claimed: The described method of producing a metal strip, consisting in subjecting a rod to a reducing pressure of forging effect which thins and flattens it and simultaneously subjecting it to a reacting pressure which limits the extension as the pressure action takes place while at the same time permitting the material being reduced to flow laterally in a direction at right angles to the reducing pressure, whereby the cross sectional arm of the product after it is substantially rolled is the same as the cross-sectional area of the rod before it was rolled.

A process and device for casting metals under an explosive-like pressure into molds has been patented by Heinrich Talla, Heilbronn-on-the-Neckar, Germany, in which is claimed: A process for casting liquid metal or other melting materials into molds, consisting in filling a quantity of metal into the mold by the force of the explosion of a solid explosive material said material being ignited in the loading space by the hot metal.

Patent No. 1,217,611, on a guide for rolling mills, recently issued to Walter Wallace Leck, of Steelton, Pa.

Patent No. 1,217,581, on process of making clad metals, has been granted to Byron E. Eldred, of New York, N. Y., in which is claimed the following: The process of making clad metals which comprises placing a body of steel in a mold, placing a body of an unlike, non-ferrous high melting metal of somewhat lower melting point in contact therewith, raising the temperature until the second-named metal melts and cooling the mold and contents from below upward by abstraction of heat from the bottom thereof while still supplying heat to the residue of the mold so that the topmost layer of molten metal shall be the last to solidify.

Preheating of air for hot-blast stoves of blast-furnaces, patent No. 1,217,039, has been granted to Edward E. Marshall, of Philadelphia, Pa., in which is claimed: The combination with a blast furnace and hot blast stoves employed therewith, of a pre-heating device for air, means for delivering heated air from said pre-heating device to said hot blast stoves, a connection between the furnace and the pre-heater for the passage of waste gas direct to said pre-heating device, burners for the latter discharging into said pre-heating device, a conduit connecting the hot blast stoves with the blast furnace, and valves controlling the passage of air to and from said hot blast stoves.

Patent No. 1,216,667 on process of treating ores, has been granted to George F. Downs, of Buffalo, N. Y., in which he claimed among other features: The process of treating ores comprising advancing the material to be treated within a converting chamber toward and through a tuyere zone by two movements, namely, an advance movement longitudinally of the converter chamber and a tumbling movement substantially at right angles to said longitudinal movement; applying heat to said mass from gases moved longitudinally within said chamber and in reverse direction to said advance movement to progressively heat and produce conversion in said constantly-moving and tumbling mass; and tuyere-blasting the mass while so advancing and tumbling to produce violent agitation, breaking-up and final completion of the desired chemical change.

Martin E. Feilman, Donald Bagley and A. H. Smith, of London, England, have been granted patent No. 1,216,667, on apparatus for purifying blast-furnace gases, the following being claimed: In an apparatus for purifying blast furnace gas or other similar gases, the combination of a closed casing having inlet and outlet openings for the gases passing to and from said casing, traveling bands or tapes moving within the casting for collecting dust or other matter from said gases, and means coöperating with the bands outside the casing for removing such collected matter.

A method of treating metals and other materials by heat has been patented by J. H. L. DeBats, of Zelienople, Pa., bearing patent No. 1,216,086, in which is claimed: The method of treating metal or metal bearing substances by heat, consisting in placing the substance and solid fuel in a closed chamber, withdrawing the products of combustion from said chamber mechanically by suction, admitting air to the fuel in said chamber, and regulating the volume and velocity of the air supply independently in a manner to maintain a lower pressure within said chamber than externally and to control the rate of combustion and the resulting temperature.

Steel Plant Incorporations and Construction

South Chicago, Ill.—The Iroquois Iron Company plans to build a 400-ton blast furnace, to bring the total number of stacks at this plant up to six. Auxiliary equipment for the additional unit will be secured.

Bettendorf, Iowa — The Bettendorf Company has issued $1,500,000 to provide an increase in working capital, presumably to be used in adding to present equipment for the manufacture of steel, steel castings and other material used in its car frames and allied products.

Sparrows Point, Md.—The Bethlehem Steel Company expects to begin production in its new tin mill at this place about the first of June. The plant will make about 4000 tons of tin plate per month.

Lowell, Mass. — The Hy-Carbo Steel Company has been incorporated here by C. H. Bagshaw, Isaac E. Higgins and M. C. Bagshaw. Capital stock is given at $20,000.

Waverly, N. J. — The Carnegie Steel Company, general offices at Pittsburgh, Pa., has filed plans for a one-story shop addition, 24x60 feet, to be erected in connection with that company's warehouse here.

Buffalo, N. Y. — The Donner Steel Company, W. H. Donner, president, expects to operate its new blast furnace shortly, and the plate mill is being rushed to allow it to start rolling in May. The remaining open hearths and mills will be rushed to completion as soon as the necessary heavy equipment can be secured.

Dunkirk, N. Y. — The Atlas Crucible Steel Company, D. W. Lathrop, vice president, plans an addition for increased manufacture of tool steel, and will add one story to its electric steel section.

Millbrook, N. Y.—The Penn Steel & Iron Company has been formed with a capital stock of $155,000 to manufacture iron and steel and engage in the transportation thereof. F. H. Butehorn, G. F. Jebbett and A. E. More, 20 Arden street, Manhattan, are incorporators.

Niagara Falls, N. Y. — The Titanium Alloy Manufacturing Company has awarded contract to the Peckham Construction Company for the erection of additional space to include two-story buildings to cost about $75,000.

Syracuse, N. Y. — The Semet-Solvay Company, has been authorized to increase its capital stock from $10,000,000 to $20,000,000, to allow for additional expansion. The company manufactures and installs retort coke ovens.

Cleveland, Ohio — The River Furnace Company has secured a large plat of ground on East Forty-ninth street, which it is understood to be holding for future extensions.

Ironton, Ohio. — The Ironton Solvay Coke Company has been incorporated to build a by-product coke plant here. The capitalization is given as $2,000,000.

Niles, Ohio — The Western Reserve Steel Company, recently acquired by the Brier Hill Steel Company, Youngstown, Ohio, is adding two new hot mills.

Conshohocken, Pa. — The J. Wood & Brothers Company, of this city, has been taken over by the Alan Wood Iron & Steel Company, Philadelphia, Pa., which will operate its old plant here in conjunction with the one recently purchased.

Glassmere, Pa.—Articles of incorporation have been granted the Acme Steel Company, incorporated for $200,000 by G. H. McFetridge, J. J. Rattigan, J. F. Peffer, T. B. Helper and Paul Newcomer.

Philadelphia, Pa. — The Midvale Steel Company is taking bids for a testing machine shop, to be one-story and 65x80 feet in extent.

Pittsburgh, Pa.—The Jones & Loughlin Steel Company is building six 50-ton open hearth furnaces at its Soho works, to provide steel for the 128-inch plate mill to be erected there.

Sharon, Pa.—The Sharon Steel Company is the name of the company holding the Sharon Steel Hoop Company and the Youngstown Iron & Steel Company, Youngstown, Ohio. Severn P. Ker is president of the new company, although other official changes are expected. The company will operate both plants from the Sharon offices.

Warren, Pa.—The Electric Steel Company, R. T. Harris general manager, 101 Liberty Street, is taking bids for plant equipment, to include machinery for the manufacture of electric steel and electric steel castings.

Dayton, Tenn. — The Dayton Coal & Iron Company, bankrupt, has been purchased by Francis C. Carey and others of Minneapolis, Minn. The furnaces, last active in 1913, will probably be put into shape for a campaign, provided the sale is confirmed by the bankruptcy court.

Hamilton, Ont.—The Carbon & Alloy Company, Ltd., plans to expend $100,000 on buildings shortly, and is in the market for compressors, cranes, furnaces, conveyors and other equipment.

Montreal, Quebec—The Standard High Speed Steel Hardening Company, Ltd., has been incorporated for $150,000 by A. Fortin, F. Willdon, F. Gerin and others.

IRON AND STEEL QUOTATIONS

COMPARED WITH PRICES OF A MONTH AGO

PIG IRON.

Pittsburgh*—	**February 22**	**March 26**
Bessemer	35.95@ 36.95	37.95@ 38.95
Basic	30.95@ 31.95	32.95@ 33.95
No. 2 foundry	33.95@ 36.95	37.95@ 38.95
Malleable	31.95@ 32.95	35.95@ 36.95
Gray forge	31.95@ 32.95	32.95@ 33.95
Ferro-silicon, 50%	225.00@250.00	250.00@300.00
Ferro-silicon, 10%	46.00@ 47.00	53.00@ 55.00
Ferro-mang., 80%	175.00@185.00	300.00@350.00
Spiegeleisen, 20%	65.00@ 70.00	70.00@ 75.00

* Pig iron prices quoted here are at Pittsburgh, with freight rate from Valleys to Pittsburgh, 95 cents added.

Virginia Furnaces—		
Basic	27.75	32.25@ 32.75
No. 2X	29.50@ 30.00	35.50@ 36.00
No. 2 plain	29.00@ 29.50	35.50@ 36.00
Gray forge	27.00@ 28.00	30.50@ 31.00
Philadelphia (del.)—		
No. 2X foundry	32.00@ 33.00	39.00@ 40.00
No. 2 plain	31.50@ 32.50	38.00@ 39.00
Basic	30.50@ 31.00	35.50@ 36.00
Gray forge	29.75@ 30.75	33.50@ 34.50
Chicago (at fur.)—		
No. 2 foundry	33.00	37.00
Malleable	33.00	37.00
Basic	33.00	37.00
Cincinnati (del.)—		
Northern No. 2 fdy	32.26	37.26
Basic	34.26	37.26
Nor. malleable	34.26	37.26
Birmingham—		
No. 2 foundry	23.50@ 25.00	30.00@ 31.00
No. 3 foundry	33.00@ 24.50	29.50@ 30.50
Gray forge	22.50@ 24.00	29.00@ 30.00
STEEL.		
Tons of 2,240 lbs., at Pittsburgh.		
Bessemer billets	65.00@ 70.00	65.00@ 70.00
Open hearth billets	65.00@ 70.00	65.00@ 70.00
Forging billets	90.00@ 95.00	90.00@ 95.00
Sheet and tin bars	65.00@ 70.00	65.00@ 70.00
Wire rods	75.00@ 80.00	80.00@ 85.00
FINISHED PRODUCT.		
Tons of 2,000 lbs., at Pittsburgh.		
Skelp, grooved	65.00	70.00
Skelp, sheared	70.00	75.00
Sheets, No. 28	95.00@100.00	100.00@110.00
Galvanized sheets	125.00@140.00	125.00@150.00
Shapes	70.00@ 80.00	72.00@ 75.00
Plates	75.00@ 80.00	95.00@105.00
Hoops	75.00	67.00@ 70.00
Bands	65.00	75.00@ 80.00
Steel bars	60.00@ 65.00	67.00@ 75.00
Iron bars	65.00@ 68.00	70.00@ 75.00
Per lb. on large orders:		
Tin plate	7.50@ 8.00	7.50@ 8.00
Plain wire	3.05	3.25
Galvanized wire	3.65	3.85
Wire nails	3.00	3.20
Galvanized nails	4.00	4.20